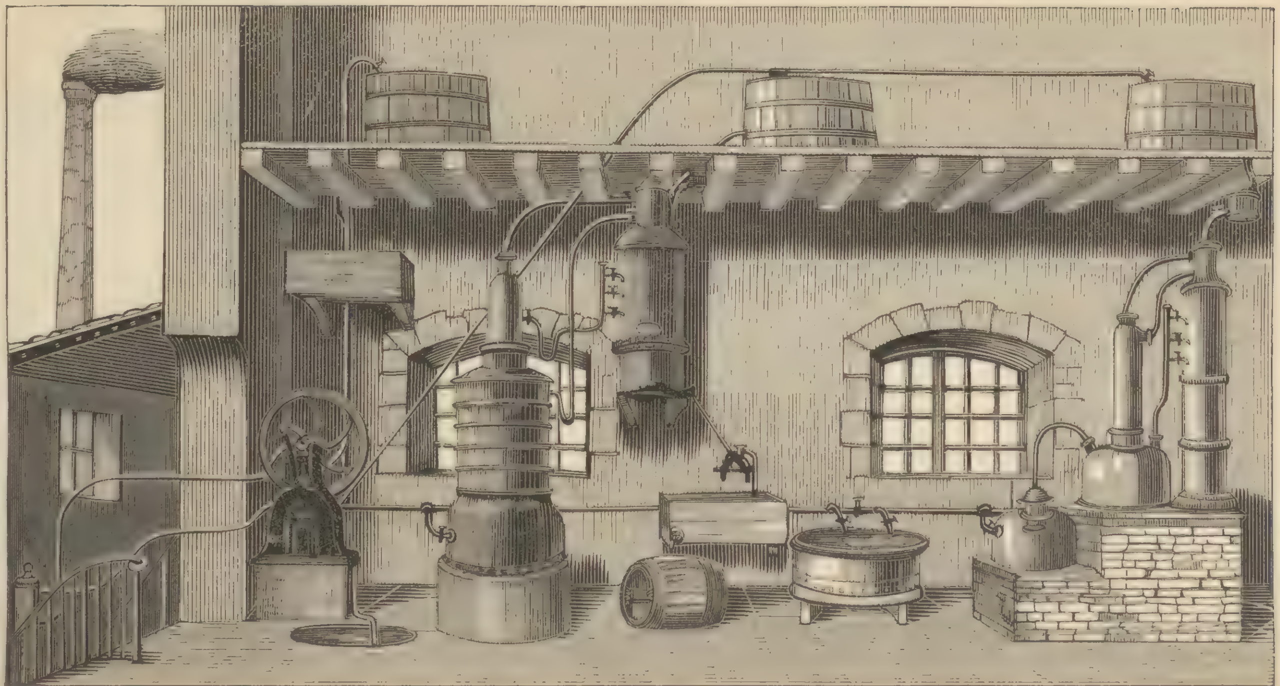
A TREATISE

ON THE

MANUFACTURE AND DISTILLATION

OF

ALCOHOLIC LIQUORS.



A BRANDY DISTILLERY. (Page 103.)

A TREATISE

ON THE

MANUFACTURE AND DISTILLATION

OF

ALCOHOLIC LIQUORS:

COMPRISING

ACCURATE AND COMPLETE DETAILS IN REGARD TO ALCOHOL FROM WINE, MOLASSES, BEETS, GRAIN, RICE, POTATOES, SORGHUM, ASPHODEL, FRUITS, ETC.

WITH THE

DISTILLATION AND RECTIFICATION OF BRANDY, WHISKEY, RUM, GIN, SWISS ABSINTHE, ETC.,

THE

PREPARATION OF AROMATIC WATERS, VOLATILE OILS OR ESSENCES, SUGARS, SYRUPS, AROMATIC TINCTURES, LIQUEURS, CORDIAL WINES, EFFERVESCING WINES, ETC.,

THE

AGING OF BRANDY AND THE IMPROVEMENT OF SPIRITS, WITH COPIOUS DIRECTIONS AND TABLES FOR TESTING AND REDUCING SPIRITUOUS LIQUORS, ETC. ETC.

TRANSLATED AND EDITED FROM THE FRENCH OF

Pierre

MM. DUPLAIS, AINÉ ET JEUNE.

BY

M. McKENNIE, M.D.

TO WHICH ARE ADDED THE

UNITED STATES INTERNAL REVENUE REGULATIONS FOR THE ASSESSMENT AND COLLECTION OF TAXES ON DISTILLED SPIRITS.

ILLUSTRATED BY FOURTEEN FOLDING PLATES AND SEVERAL WOOD ENGRAVINGS.

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PREFACE.

Alcohol has become an article of prime necessity in many of the arts and manufactures, and enters largely, in one form or another, into the daily consumption of our people. This industry is pre-eminently based upon scientific principles, which, if correctly understood, will insure greatly increased profits to the producer, and, if honestly applied, will tend in no small degree to mitigate the evils which grow out of the use of the article, often prepared by so-called practical distillers, some of whom are ignorant and others vicious. There are, however, many intelligent and honorable exceptions—men who, knowing how, manufacture pure and good liquors.

The undersigned, anxious to see a really good book on this subject placed in the hands of American distillers, rectifiers, and compounders, as well as dealers in wines and liquors, has been unable to find any work in the English language which seemed at all adequate to this requirement, or to the actual wants of this industry at the present day. In his extremity, he has naturally turned to the technical literature of France, among whose people great intelligence and skill have long been brought to bear in their applications of the principles of science to the various arts. In the book of MM. Duplais, he believes he has found this great desideratum.

These authors, by reason of thorough education in all those departments of science on which the art of the distiller depends, as well as by practical skill in every manipulation requisite for their application, are eminently

deserving of the exalted position which they have long held in their own country, and the translator feels honored by being permitted to introduce their really great work to the American public.

The recent rapid development in this country of many new and important branches of industry, the attention paid to every source of improvement by our people generally, and the great impetus given within a few years past to the growth of the vine, would seem to indicate that the present moment is most opportune for the appearance of just such a book. He believes that this can admit of no doubt. The soil and climate of various parts of our country find their parallels in the wine and brandy producing districts of Europe, and appear to be well adapted to the production of all those substances which may economically enter into the manufacture of alcohol.* The processes and apparatus which are profitably applied in the old world, will doubtless find enterprising men to make use of them in the new, when once properly brought to their notice.

In preparing this translation for the press, it has been thought best to omit a few processes which had been found to be either unprofitable or inapplicable in this country. Then, again, the chapters on the French excise regulations have of course been substituted by our own internal revenue regulations. The appendix contains, in addition to this matter, many very full and valuable tables and other information without which it is believed that the book would have been incomplete.

* We have seen wine and brandy prepared from grapes—Concord, Delaware, and Diana—raised by William Hotopp, Esq., near Charlottesville, Virginia, which would, we believe, be considered of excellent quality in the best vineyards on the Rhine.

The translator feels it due to himself, that he should make acknowledgment to Messrs. G. B. Stuart and R. W. Burke, of Augusta County, Virginia, to whom he is indebted for much valuable information which was absolutely essential to him in the successful prosecution of his undertaking. Both of these gentlemen, by their intelligence, integrity, and skill, have acquired a high reputation in their business, of which they may well be proud, and which under a more liberal system of excise laws would insure to them ample and profitable returns for their efforts to develop an important source of national wealth.

The handsome typography and paper, and the neatly engraved illustrations of this volume, as well as the many and expensive tables added to it, indicate that the publisher is fully alive to the obligations which he owes to that public which has so generously sustained him in his earnest efforts to advance the cause of practical science among our people, by giving them an industrial literature worthy of the name.

M. McK.

University of Virginia,
June 25, 1871.

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A TREATISE

ON THE

MANUFACTURE AND DISTILLATION OF ALCOHOLIC LIQUORS.

PART I.

CHAPTER I.

ALCOHOL.

UNDER this name modern chemists designate a spirituous liquid of any degree or density. The terms *brandy*, *spirits of wine*, of *molasses*, *beets*, or *whiskey* employed in the market to designate the varieties and extreme degrees of concentration of the same liquid, are replaced in scientific language by this generic term.

The word *alcohol* is of Arabic origin, and signifies a *very subtile* or *highly divided body*. It was formerly employed to indicate the extreme tenuity given to certain powders. Boërhaave used it to express the inflammable principle reduced to its simplest terms without being decomposed.

Pure or *anhydrous alcohol* is a transparent, colorless liquid, of a strong and penetrating odor; of a warm and acrid taste, very volatile; when exposed to the air it evaporates by degrees; inflammable by contact with flame, it burns with a white flame, leaves no residuum, and disengages much heat. When diluted with water it burns with more difficulty, and its flame is blue and less brilliant. It is very sensitive to the influence of changes of temperature; expanding under the effects

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of heat, contracting in the cold. Exposed to a temperature of 173° Fahr. (78° cent.) under a pressure of $0^m.76$ it boils and evaporates entirely. It has never been frozen.

The specific gravity of pure alcohol at 60° Fahr. (15°.5 cent.) is 0.793. Its elementary composition is

Carbon	52.32
Oxygen	34.38
Hydrogen	13.30
	100.00

Pure alcohol is decomposed by passing it in the form of vapor through a porcelain tube heated to redness. It is converted into carbonic acid, carburetted hydrogen, and water. These products indicate the constituent principles of alcohol in a positive manner.

Alcohol mixes with water in all proportions. The increase of temperature which takes place in the mixture indicates the condensation and complete union of the two bodies. The volume of the mixture is in fact much less than the sum of the volumes of the original liquids. The maximum of contraction takes place in a mixture of 580.625 parts of alcohol and 674.880 parts of water. 100 volumes of this mixture contain 53.939 volumes of alcohol, and 49.836 volumes of water; in other words, 103.775 volumes are reduced to 100.

As has been said above, spirits and brandies* are alcohols of different *titles* or degrees of strength, the former known in commerce as *rectified spirits* (*trois six*), at 85 or 95 degrees of the centesimal alcoholmeter. The second vary from 40 to 60 degrees, according to the nature of the substances which have been used to manufacture them. The chapters on the distillation of alcohols and brandies, and the reduction of spirits will give more ample details in regard to this subject.

Alcohol is of the greatest importance in chemistry. Next to water, it is the most general solvent. It dis-

* The term "brandy" is used here as generic to indicate the spirit from grape. From molasses comes rum; from grain, whiskey, &c.

solves iodine, the resins, volatile oils, vegetable alkalies, almost all of the acids, &c. It precipitates from their solutions gum, starch, albumen, gelatine, and many other substances. On account of these properties alcohol is an invaluable agent in analysis.

It has numerous applications in medicine and the arts; it serves as the vehicle for a host of remedies, forming the bases of the ethers, tinctures, aromatic spirits, &c. It is never employed pure for these purposes, but of different degrees of strength, as indicated by the alcoholmeter. It enters into the preparation of liquors and cordials for the table, absinthes, perfumed extracts, and vinegars, and aromatic spirits, and is therefore used in very large quantities by the perfumer and liquorist. It is used by the anatomist and naturalist to preserve their preparations from putrefaction. Finally, it enters into the manufacture of varnishes, stearine candles, gun caps, &c., for which large quantities are consumed.

Alcohol is found in all substances (vegetable or other) which contain sugar or glucose; it is the product of the decomposition of the saccharine principle which takes place during the *vinous* or *alcoholic* fermentation. It does not exist ready formed in these substances, but only after they have passed through this kind of fermentation, and it may, by reason of its very great volatility, be separated by distillation from the water with which it is united. It is on this principle that is founded the extraction of this product.

All vinous liquors which yield alcohol by distillation do not furnish it in equal quantities, the result depending on the quantity of saccharine matter contained in the liquid. The larger the proportion of sugar the greater will be the alcoholic product, the latter being derived entirely from the former.

Among the vegetables employed in Europe for the production of alcohol, the *grape* holds the first place, the beet and rice come next. Potatoes, artichokes, carrots, turnips, the stalks of Indian corn, sorghum and the daffodil, although producing notable qualities of alcohol, are much less employed. It is the same of the cereals

and fruits in general. The molasses of the sugar factories and refineries is almost entirely converted into alcohol, and takes rank after the beet and rice.

In the United States, on the other hand, potatoes, Indian corn, and the cereals furnish almost the whole of the alcohol found in the market, while large districts of country depend on the product of the orchards for their brandy.

Hereafter we shall examine the method of obtaining alcohol from each of the substances named above. It is impossible to obtain anhydrous alcohol by a simple distillation. Whatever may be the merit of the rectifying apparatus, it is necessary to have recourse to very deliquescent salts or other substances which have a great affinity for water, such as carbonate of potash, acetate of potash, chloride of calcium dried and melted, quicklime, clay dried and finely divided, &c.

Pure alcohol being very difficult to find in the market, the following, if not the most economical, is at least the most convenient and prompt method for procuring it:—

The spirit is allowed to macerate at a gentle heat for two days upon one-tenth of its weight of carbonate of potash dried by the fire (100 grammes to the litre of alcohol at 85 degrees). It is agitated from time to time, then distilled in a *water bath*, to draw off all the alcohol marking 94 degrees. To this alcohol is then added pulverized quicklime in the proportion of 500 grammes to the litre, leaving them in contact for two or three days in a *hot room*, and after decanting the alcohol from the calcareous deposit it is distilled very gently. The product is perfectly pure dephlegmated alcohol, that is to say, absolutely free from water.

When we wish to ascertain if alcohol contains any water, a fragment of caustic baryta is placed in contact with the liquid. If it contains no water the baryta is not altered; on the contrary, if any water is present it whitens, swells, becomes hydrated and falls into a powder. The phenomenon is more marked in proportion as the quantity of water is greater.

The degree of concentration of alcohol is ascertained

by the use of instruments especially adapted to the purpose, the uses of which will be described in the article on the "*Determination of the alcoholic strength of liquids.*"

Alcohol is a diffusible stimulant. Its energy varies with the quantity of water with which it is mixed. When concentrated it acts as a caustic on the living tissues of the animal economy, coagulating the albumen, and depriving them of their water. By injection into the veins it causes sudden death by coagulating the blood. Its introduction into the stomach almost always causes death. Taken properly its action is restricted, especially to the sensitive and intellectual organs.

"Alcohol," says Brillat-Savarin, "is the king of liquids; it excites the taste to the highest degree; its various preparations have opened up to mankind new sources of enjoyment; it supplies to certain medicines an energy which they could not have without it; it has become in our hands a formidable weapon; for the nations of the new world have been almost as much overcome and destroyed by brandy as by fire-arms."

CHAPTER II.

FERMENTATION.

An intestinal reaction which occurs spontaneously in any vegetable or animal substance under the influence of a peculiar principle, called *ferment* aided by heat, whence are produced certain new substances which were not originally contained therein.

As the periods of decomposition are characterized by some peculiar predominating principle, the distillers distinguish four kinds of fermentation, viz: The *saccharine* or glucosic, the *vinous* or alcoholic, the *acid* or acetic, and the *putrid*.

Although the vinous or alcoholic fermentation most

especially concerns the distiller, it is nevertheless indispensable, on account of the different alcohols extracted from starch and the cereals (of which we shall speak hereafter), that he should be perfectly familiar with the laws which govern the saccharine fermentation. As to acid and putrid fermentation, they may be considered, so far as the distiller is concerned, among the accidents to which we must refer further on.

Saccharine or Glucosic Fermentation.

This fermentation is developed in starch dissolved in water, when brought in contact either with malt (germinated barley), gluten, or with a mineral or vegetable acid, agents which act as a ferment or leaven.

It also takes place in the act of germination of seeds and the ripening of fruit. It is effected without any visible movement in the material, solid or fluid, and without disengaging carbonic acid.

The operation of *saccharification* is nothing more than the transformation of the amylaceous matter into glucose, that is to say, a true saccharine fermentation.

The substances just named are not the only ones which may, under the influence of certain reagents, be transformed into sugar; gum, pectine, cellulose, etc., also enjoy this property.

Green or unripe fruits contain a very small proportion of sugar, and, on the other hand, a considerable quantity of gum, mucilage, pectine, starch, lignine, and a great amount of free acid. During the maturation a part of the acid disappears under the influence of heat and the oxygen of the air, the cellular tissue diminishes and the quantity of sugar increases in such a manner that instead of ligneous and acid fruits we have, if the maturation is complete, some weeks after gathering them, fruits which contain a sweet and syrupy juice enclosed in tough or leatherlike envelopes.

The following table will exhibit the proportions of sugar contained in 100 parts of certain fruits, both green and ripe:—

	Green.	Ripe.
Pears	6.4	11.5
Currants (red)	0.5	6.25
Apples	4.9	11.
Apricots	6.6	16.5
Peaches	0.6	11.6
Cherries	0.12	18.11

Experiment has demonstrated that the maturation of fruits is analogous to that produced by the reaction of feeble acids upon gum, starch, and the shavings of wood.

Vinous or Alcoholic Fermentation.

Among the proximate principles of organic substances, sugar alone gives occasion to vinous fermentation from which alcohol is derived.

This fermentation cannot proceed without the concurrence of five agents acting, each in a different direction, the union of which is, however, indispensable, viz:—

1. Sugar or saccharine principle; 2. Water; 3. Heat; 4. A ferment; and 5. Atmospheric air.

If one of these agents is suppressed, the vinous fermentation will not take place, and consequently no alcohol will be produced, whatever be the materials used or the processes followed. The rôle of each is of more or less importance, and the success of the fermentation depends absolutely on their employment and combination.

We shall now examine, in turn, the part played by each of these agents in the fermentation in order to bring about the formation of alcohol.

Sugar.—As we have said above, sugar is the only constituent element that can produce alcohol. The rest are mere auxiliaries to the decomposition.

According to the principles of chemistry, as understood to-day, sugar is a substance which, when dissolved and brought in contact with a ferment, possesses the property of being transformed into alcohol and carbonic acid; entirely composed of oxygen, carbon, and hydrogen. It consists by weight of carbon 42.47; oxygen 50.73; hydrogen 6.90.

There are two marked varieties of sugar, the common or crystallizable and the uncrystallizable sugar.

The first of these, generally obtained from the cane and beet, is also found in the stalks of sorghum, Indian corn, etc. The second is met with in the grape, pear, and other fruits, in the potato, in beans and in seeds.

From a number of vegetables sugar may be extracted, differing more or less from that derived from the cane, as the maple, beet, grape, or potato. This sugar will also undergo the vinous fermentation, and alcohol may be obtained from it by distillation.

Again, there exist certain sugars susceptible of fermentation which, although differing entirely from the preceding, are employed in a fluid state in the form of syrup or juice. These can neither be crystallized nor solidified.

Sugar is transformed into alcohol by the separation of a part of the carbon or oxygen which it contains. In the course of this transformation it loses half its weight in gas. This result may serve to make known the quantity of alcohol of any desired strength which may be obtained from a properly fermented vat.

The liquid which the vat contains before fermentation having been weighed by means of a densimetre or saccharometre (*pese sirop*), it is easy to calculate the weight of the sugar which it contains in solution, and the half of this weight will give approximately the weight of pure alcohol which the fermentation will produce; yet it must be observed that practice often destroys the calculations of theory, because the liquid tested may contain tartrate of potassa, or other foreign matters, and consequently less sugar than is indicated by the saccharometre; moreover, it is proper to take into account the acetic acid which is formed at the expense of the alcohol as well as the loss by evaporation.

Water.—Of all natural agents for the disorganization of material substances, water occupies the first place. The presence of this solvent *par excellence*, is not only indispensable, but the more or less active and complete change of the sugar into alcohol is dependent on the proportion in which it is used.

The fermentation is rapid or slow in accordance with the quantity of water employed. To hasten or retard the operation, it is only necessary to increase or diminish the dose, by adding water in the first case, and evaporating it in the second; the best guide being the saccharometre.

In order to exhibit more clearly the action of water in the course of the vinous fermentation, we shall proceed to give the results of some experiments made by M. Duplais in June, 1854.

Five fermenting vats, of a capacity of 25 hectolitres each, situated in a place having an even temperature of 20° C., received each 300 kilogrammes of molasses from the sugar refineries (215 litres at 42 degrees), and a quantity of water sufficient to make, in No. 1, 600 litres, marking on the saccharometre 15°; in No. 2, 750 litres marking 12°; in No. 3, 1000 litres marking 9°; in No. 4, 1500 litres marking 6°; and in No. 5, 2250 litres marking 4°.

The following table will exhibit the duration of the fermentation and the alcoholic product of each vat:—

Vat.	Quantity of liquid.	Duration of experiment.	Alcoholic product.	Proportion per 100.
1	600 litres at 15°	8 days	78.75 litres	26.25
2	700 " " 12	5 "	83.55 "	27.85
3	1000 " " 9	3 "	90.45 "	30.15
4	1500 " " 6	2 "	93.15 "	31.05
5	2250 " " 4	1 "	93.90 "	31.30

Thus it is evident that the proportion of water exercises a great influence, both on the duration and on the products of the fermentation, and although it requires more fuel to distil 1500 litres of a liquid which will produce 93.15 litres of alcohol, than for 750 litres which will produce 83.55 litres, the increase of fuel is more than compensated by the increase of the product.

The choice of water for the vinous fermentation is not

a matter of indifference. That which contains organic matters in solution should be rejected, on account of its tendency to run into the putrid fermentation. Water strongly impregnated with lime, or salts of iron, should also be rejected. Without the employment of filtered water, as for cordials, liquors, etc., it is indispensable to have it pure and clear to obtain a good result from the fermentation.

This article cannot be closed without one observation of very great importance. In distilleries where the fermenting vats are heated by steam, if the pipes are not sufficiently inclined, the water resulting from the condensation of the steam in them may check or even arrest the fermentation. This inconvenience may be abated by the use of a "drip."

Heat.—In the disorganization of organic substances, the intervention of heat is as important as that of water.

Like water, heat may be the cause of hastening or retarding the vinous fermentation. Below a temperature of 12° C. it is checked, and ceases entirely with a very cold temperature. Between 15° and 18° C. fermentation sustains itself, and becomes more lively and more perfect beyond this point. It is not, however, necessary to exceed 28° or 30°, because this high temperature excites the acetic fermentation and will become very injurious. This inconvenience may be obviated by cooling the mass by means of a coiled pipe placed in the vats, in which cold water is caused to circulate, as is done in many English distilleries.

Heat is retained longer in large masses than in small, and the fermentation becomes of itself the source of heat, by reason of the rapidity of the decomposition of the sugar; this rapidity being also in proportion to the mass. Hence it follows that the heat should be increased in inverse proportion to the bulk of the mass to be fermented.

In general, with some exceptions which will be indicated hereafter, the heat which should be applied to fermenting vats, is as follows:—

A vat of 10 hectolitres . . .	25° to 30° C.
" 20 " . . .	20 " 25 "
" 40 " . . .	18 " 20 "
" 60 " . . .	15 " 18 "
" 100 and above. . . .	12 " 15 "

The power which organic substances possess of fermenting under the influence of heat and contact with the air, and thus, when in this condition, of producing the same phenomena in other substances, will disappear entirely when they are submitted to the temperature of boiling water. This general rule has no exception.

If we take a substance naturally susceptible of fermenting, of putrefying, and being decomposed, when left even for a moment exposed to the action of the air, and if, after having arrested the movement of incipient change, by means of a temperature of 100° C., we prevent all access of oxygen which alone can cause a revival of this movement of decomposition, the substance will preserve, as it is easy to conceive, for an indefinite period of time, the condition and properties which it possessed at the moment when it was submitted to the temperature of boiling water. In fact the substance is in itself incapable of spontaneous motion; so long as no external cause acts on its atoms, they will preserve their place and original character.

When a bottle is filled with the fresh juice of the grape, hermetically sealed, and suffered to remain some hours in boiling water, or at least until the *must* has acquired the same temperature as the water, the small quantity of oxygen contained in the air which remains in the bottle is absorbed during the action of the heat by the elements of the must.

In this manner the alteration of the must is preventive; it will no longer ferment; it will preserve its sweet taste, and this condition will be maintained until the bottle shall be opened, that is to say, until the moment when the liquid shall be brought into a new contact with the external air. But setting out from this time the liquid will undergo the same modifications as recent must; in other words, it will be, after some hours have

elapsed, in full course of fermentation, which may, however, be interrupted and caused to cease entirely as at first, by means of a new ebullition.

The Air.—By reason of its oxygen, the air is the vehicle of decomposition of organized bodies. It acts as a leaven in the vinous fermentation, for which it is essentially the initial force. Nevertheless, when its oxygen has given the impulse, it ceases to be necessary in the different periods through which the fermentation passes. This last, notwithstanding the exclusion of the air, continues its progress without interruption.

The juice of the grape, so long as it is protected by its envelope from contact with the atmospheric air, experiences modifications which are scarcely appreciable. The berry only dries by degrees. But it is sufficient to change all the properties of this juice, if the envelope is opened with the point of a needle. When it is protected from contact with the air, and consequently preserved from the chemical action which the oxygen of the air exercises upon one of its proximate principles, the must of the grape will be preserved indefinitely; for in the absence of a disturbing cause, the elements can experience no change, whatever be their facility of assuming new arrangements. But when it is exposed to the air and subjected to a proper temperature, there is produced an active disengagement of gas, accompanied by movement in the liquid, and all the sugar will disappear. The juice of the grape now contains a quantity of alcohol which is in direct proportion to the sugar which it contained before.

Nevertheless, if the contact of the air is indispensable to set up the vinous fermentation, particular care should be taken to prevent this contact when the fermentation has commenced; by this precaution will be prevented the formation of acetic acid, which is always produced at the expense of the alcohol, and then becomes itself a most active leaven for the acetic fermentation. It is advisable, then, during the continuance of the fermentation, to abstain as much as possible from uncovering the vat, and producing any movement whatever that may

displace the layer of carbonic acid gas interposed between the liquid in fermentation and the atmospheric air. The period most to be apprehended for the formation of acetic acid in the vinous fermentation, is towards the end of the operation, for then the action of the atmosphere is exercised only on the alcohol already formed and favors its transformation into acetic acid.

Weak musts extracted from various substances in which the vinous fermentation is completed cannot bear, by reason of the small quantity of alcohol which they contain, contact with the air; in them the acid fermentation begins as soon as the vinous fermentation has ceased, and we may almost affirm that the two fermentations, under the circumstances indicated, in some measure progress side by side.

Ferment.—The term ferment is understood to apply to any substance which, when placed in a liquid capable of being fermented and properly arranged, causes it to ferment with more activity and energy than it would have done if left to itself, and thus shortens this operation.

The ferment is a substance in a state of putrefaction, whose atoms are in continual motion, and which has the property of causing the decomposition of sugar and its conversion into alcohol. May not this substance, which has not been clearly defined, be considered as peculiar, or rather as a modification of certain animal organisms? This last hypothesis is admitted by many philosophers, because many animal substances, when in a state of decomposition, act as a ferment on sugar.

According to the microscopic observations of Quevenne, Turpin, and others, upon substances in a state of fermentation, the ferment is endowed with vital action and partakes of the nature of the animal or vegetable; it appears to be organized, and to exist and develop itself it requires similar nourishment.

"This azotized substance, which exists as a gum in the greater part of organized matters, when placed under certain influences and in proper conditions, is developed, modified, and acts as we shall demonstrate hereafter.

Sometimes it exists already formed, but during the course of fermentation it loses its quality of ferment. Sometimes, on the other hand, it not only exists and acts, but, during the fermentation, it develops itself until it acquires a weight five, six, and even sevenfold more than it had at the beginning.

"In respect to the ferment we recognize three conditions in the phenomena of fermentation; in the first, the ferment does not exist, but may be produced spontaneously, as in the case of saccharine fruits; in the second, the ferment exists and acts, but is not reproduced: this occurs when sugar is mixed with the leaven of beer; and in the third, the ferment may originate, act, and reproduce itself, as happens in the course of the manufacture of beer."

In general the ferment does not act by virtue of its peculiar chemical nature, but simply as the cause of an action which extends beyond the sphere of its own decomposition; it impresses on the organic substances with which it may be brought in contact the state of decomposition in which it happens to be. "The ferment itself takes no part in the chemical changes which it provokes, and we can find, neither in the laws of affinity nor in the forces of electricity, light, or heat, any legitimate explanation of its effects."

Whatever may be the nature of the ferment, it is very evident that to its action, in the course of fermentation, is due the change of sugar into alcohol. Ferment, as we have already said, is a substance undergoing decomposition or putrefaction, the particles of which are in continual motion. This perturbation of elements, by communicating itself to the sugar, destroys the state of equilibrium of its peculiar atoms, which are then grouped in a different manner, according to their special attractions. The carbon of the sugar divides itself between the oxygen and hydrogen in such a manner as to form two more stable and intimate compounds—carbonic acid and alcohol. The elements of the ferment take no part in the formation of the products which result from the sugar during the fermentation. It is only the stimulant

which provokes the change without participating therein chemically.

The ferment most generally used is the *leaven* or *yeast* of beer. The preference of distillers for this substance is founded on its fermentable power, and on the facility with which it may be procured in the market.

Yeast is a frothy substance which is drawn up by the carbonic acid gas, and collects on the surface of the liquid during the fermentation of the worts of beer. It is to be had of the brewers either in a liquid or solid state, that is to say, fresh or dry.

Fresh yeast in a semi-fluid state is to be preferred, but it is very difficult to transport and preserve it, therefore dry yeast is most frequently used. The latter has been subjected to the action of a press, to deprive it of the beer and render it solid. In this state it is in the form of a uniform brittle paste, neither stringy nor sticky, of a yellowish-white, and having a slight aromatic odor of hops, without any mixture of an acid or putrid taste.

The fermentable power of yeast varies according to the quality of the beer from which it is derived. If it results from a strong beer, it is much more substantial, acts more gently and more certainly, and is more apt to favor a healthy and sweet fermentation. If, on the other hand, it is derived from a small beer, it acts all at once with a sort of violence, and, after having excited in the wort a hasty bubbling and kind of effervescence, it loses all its energy, from which results a loss of a portion of the spirituous principle, and is frequently followed by acidity.

The facility with which yeast passes to a state of putrefaction renders it necessary to preserve it in the cellar, or some other cool place, for a slightly elevated temperature may readily alter or corrupt it.

It may be preserved a sufficiently long time, especially as regards its freshness, when care is taken to cover it with water, which must be renewed every day. A means of preserving yeast at all seasons, and which has been employed with some success, consists in mixing this substance with very thick molasses, so as to form a

hard paste. "The ferment thus mixed with sugar or molasses," says Dumas, "will for years preserve its characteristic properties." According to M. Payen a better result is obtained by spreading out a thin layer of fresh yeast, and allowing it to dry in the open air by exposure to the sun, or in a current of slightly-heated air.

"I have," says he, "succeeded in rendering the desiccation more prompt by spreading the yeast whipped to a smooth broth on thick tables of plaster well dried, and thus rendered more absorbent." Another means has appeared to me to be at least as efficacious. It consists in mixing the whipped yeast with very dry animal black in powder (and consequently strongly hydroscopic), or with starch strongly heated and cooled in a close vessel. The drying under these circumstances is easily finished in a current of air heated to 30° or 35° C.

Whatever may be the method employed for preserving pure yeast it is very certain that it will never possess either the strength or the energy of that which is newly prepared, therefore it should never be used when fresh yeast can be obtained.

It is important to examine yeast with great care to be assured of its quality. That which is acid, or the result of a bad fermentation, should be rejected. The former is recognized as follows: A strip of litmus paper being dipped into the suspected yeast, if it is acid the blue will be changed to a permanent red; if, however, the yeast be good, fresh, and well preserved, the litmus paper will be slightly reddened, but if washed in fresh water the blue will be restored. As to that which results from a vicious fermentation it is almost impossible to detect it, unless by employing the means hereafter indicated in the article on *the phenomena of fermentation*, or when the decomposition is so far advanced in the altered leaven that the disagreeable odor which it exhales may be recognized.

Frequently the dry yeast is sophisticated. The fraud consists in the addition of rye or wheat flour, or, more likely, wheat or potato starch. This mixture is readily detected by dissolving a small quantity of the suspected

yeast in a little boiling water, and pouring into it two or three drops of tincture of iodine. If it is pure, the liquid will not change color; if, however, it is adulterated, a decided blue color will be produced.

Beer yeast is not the only substance which will cause the conversion of sugar into alcohol. All azotized substances, as gluten, albumen, fibrine, caseine, &c., possess this property in a more or less decided degree, and they will act as much more promptly as they are more alterable, and when they have already arrived at a state of incipient putrefaction.

All the vegetable juices that contain sugar enter into a state of fermentation a few hours after they have been expressed, as happens with the juice of sugar-cane, the beet, fruits, the sap of the maple, &c. This phenomenon results from the fact that these juices contain a notable proportion of nitrogenous fermentable material, which, however, does not possess the power of developing fermentation until brought in contact with the air; for, in a vacuum, or in contact with other gases than the air, these saccharine juices undergo no change, while a very small quantity of atmospheric air will in a short time determine their fermentation.

The varieties which exist in yeast, as regards the amount of ferment it contains, as well as the distance of certain distilleries from the sources of supply, oblige the distillers to prepare leaven for themselves. By this means they act intelligently, and are assured of obtaining uniform results; nevertheless we must say that leaven is never so energetic as good yeast.

The following receipt will always produce a leaven, the efficacy of which has been proven by experience:—

Malted wheat, very dry and pulverized	2 kilogrammes.
Malted barley ground and dried in a furnace	400 grammes.
Hops	250 "
Strong glue	250 "
River water	40 litres.
Good fresh and dry yeast	1 kilog. 500 grms.

Boil the hops in 24 litres of water until reduced to one-third, filter through a cloth, then, after allowing it

to cool to 36° C., work in the flour. The glue is to be dissolved in the remaining 16 litres of water at a boiling heat, and the solution mixed with the flour dough. The mass is then allowed to cool down to 24° C., and the yeast is added. The mass will very soon begin to ferment, and, at the end of twenty-four hours, will have been converted into a very good leaven fit for immediate use.

If a small quantity of this leaven is prepared at the beginning it will serve for preparing more, and by this means it may always be procured in such quantity as may be needed. It may be kept for eight days in a cool place without alteration.

The following may also be employed successfully :—

Common honey . .	5 kilogrammes.
Malt . . .	3 kilogr. and 500 grammes.
Cream of tartar .	500 grammes.
Water . . .	10 litres.

Heat the water to 50° C., then add the cream of tartar, honey, and malt ; stir the whole well together and leave it for some hours. As soon as the temperature has fallen to 24° C. cover the leaven until the fermentation is established.

The following process for the distillation of the juice of the beet, for which a patent was issued in France in 1838, may with some modifications be highly useful.

The process may be stated as follows, viz : The beet juice, marking from 6° to 7° of the areometer of Baumé (saccharometer), is introduced into the vats at a temperature of 25° C., to which are added, for a vat of 15 hectolitres :—

Sulphuric acid, at 66° .	1 kilogramme 500 grammes.
Dried beer yeast . .	2 kilogrammes 500 "
A special preparation .	2 "

The special preparation is made as follows :—

Coarsely ground rye flour	16 kilogrammes.
Wheat bran . . .	9 "
Butter (without salt) .	1 kilogramme 500 grammes.
Soft soap . . .	2 kilogrammes 500 "
Saltpetre . . .	1 kilogramme.
Boiling water . . .	10 litres.

The object of the soap and butter is to prevent the fermentation from being too tumultuous.

Phenomena of the Vinous Fermentation.

Now that we have explained the rôle of the five indispensable agents of the vinous fermentation, their combination and use, we shall describe the phenomena of the operation itself.

The vinous fermentation, as we have already said, is the result of the decomposition of sugar, the products being alcohol and carbonic acid.

These results may be easily established by dissolving some sugar in four times its weight of water, or more, according to the idea of the distiller, without, however, using too great a quantity of water, for then the fermenting mass will heat with difficulty, because it will be too watery. When the liquid marks 10° of the saccharometer its temperature should be raised, as has already been said, in proportion to the mass, that is to say, between 15° and 30° C. Take 2½ per cent. of dry and fresh yeast, and dilute it with a small quantity of the liquid which is to be fermented; beat the mixture strongly with a small whip; cover the vessel, and if the yeast is good, the fermentation will be established at the end of a quarter or half of an hour at most; if not we shall be compelled to add yeast until fermentation shall be active and tumultuous. This preparation finished, the leaven is poured into the fermenting vats, the mixture thoroughly stirred, and the vessel closed. The temperature of the mass must be kept up, and under these conditions the fermentation will not delay in establishing itself, and will run through its various periods.

Let us suppose that this experiment is performed in a flask furnished with a bent tube, which is plunged into a cistern filled with water, in order to give issue to the gas, and at the same time prevent its dissipation in the air. With the apparatus so arranged it will be easy to observe what passes.

First stage.—The liquid is disturbed, its volume in-

creases, and its temperature rises; for the heat applied to the vat to inaugurate the fermentation is not all that will act; the fermentation produces it spontaneously in proportion to the rapidity of its development, that is to say, in accordance with the more or less prompt decomposition of the sugar, and, consequently, with the quantity of carbonic acid formed. Certainly it is easy to comprehend that it is to this heat, produced by the internal movement in the vat, that is due the elevation, or, at least, the preservation of the temperature of the mass in fermentation. It is evident that without this new heat the vat would soon lose a part of its caloric, and acquire the general temperature of the place wherein the fermentation is conducted. It is, too, on this principle that we raise the temperature of the place and of the mass in proportion as the quantity is small, and the must weak.

The symptoms of fermentation then are: 1st, *increase of volume;* 2d, elevation of temperature; 3d, formation and discharge of carbonic acid gas.

This gas escapes from all points of the liquid in innumerable small bubbles, which rise to the surface and break, bringing with them particles of the ferment, and produce, according to the nature of the materials acted on, a *scum* (or foam), more or less thick, called *the cap.*

Second stage.—The vat attains its highest degree of temperature, the fermentation is in the greatest activity, the gas escapes abundantly, and the cap thickens; then the tumultuous movement subsides, the heat of the vat decreases, and this last resumes its original temperature.

Third stage.—Almost the whole of the sugar being converted into alcohol and carbonic acid gas, the fermentation is finished, the liquid acquires the temperature of the place in which the fermentation is conducted, the cap, no longer supported by the carbonic acid, falls to the bottom of the vat, the liquid becomes clear, and should, if the operation has been well conducted, that is to say, if the sugar is decomposed, be reduced to the term *zero* of the saccharometre. In this condition, if the liquid is examined, it will be found to have lost its sac-

charine taste, and to have acquired one that is more or less strong and warm, as well as a peculiar *vinous* odor.

From this point it loses the name of *must* to receive that of *wine*, whatsoever may be the character of the materials that have produced it.

The vinous fermentation having run through its different stages, if we have collected the whole of the carbonic acid gas evolved on the one hand, and, on the other, distilled the fermented must to extract the alcohol, leaving out of the calculation the foreign substances furnished by the ferment, we arrive at this result of our experiment, viz., that 100 parts of sugar will furnish 51.455 parts of pure alcohol and 48.545 of carbonic acid.

Now by establishing the quantity, in volumes, of the elements of sugar and of alcohol, we can easily account for this transformation of sugar into alcohol as indicated by Gay-Lussac:—

Composition of sugar in volumes.		Composition of alcohol in volumes.	
Vapor of carbon . .	3 vols.	Vapor of carbon . .	2 vols.
Hydrogen	3 "	Hydrogen	3 "
Oxygen	$1\frac{1}{2}$ "	Oxygen	$\frac{1}{2}$ vol.

From which it is seen that alcohol differs from sugar only in this, that it contains one volume less of the vapor of carbon and one of oxygen, proportions which are exactly those in which these two bodies combine to form carbonic acid. Wine is only sugar, less a certain quantity of oxygen and carbon.

As to the decomposed ferment, it is deposited in the form of white flocculi; but it no longer contains nitrogen as one of its elements, and, as we do not find it in any of the products, we are ignorant of what has become of it.

It may often happen that a vinous fermentation is entirely completed, although the saccharometre indicates one or more degrees, as in the fermentation of common molasses and of beet-juice. This indicates that the fermented liquid contains some salt of potash, or other substance, and that the saccharometer does not really indicate the quantity of sugar contained in the liquid, but only the specific gravity of this liquid.

So many circumstances may influence the more or less prompt decomposition of the sugar, that it is impossible to indicate precisely the time necessary for the fermentation to run through all its stages. This decomposition is dependent, first, on the saccharine richness of the must; second, on its volume; third, on the local temperature and that of the mass to be fermented; fourth, on the energy of the ferment and the quantity employed; in fact on a number of unforeseen causes.

The phenomena which we have just described are produced in all saccharine liquids which enter into a state of fermentation, whatsoever be their origin.

If we examine all the phenomena of fermentation as a whole, we arrive at a confirmation of the principle long ago laid down by Laplace and Berthollet, viz: "*That an atom set in motion by any force whatsoever, may communicate its own motion to another atom which may be in contact with it.* This is a general law of dynamics which embraces every case in which the resistance (*vital force, affinity, electric force, force of cohesion*) which opposes a motion is sufficient to arrest it." (LIEBIG.)

Accidents of Fermentation.

The vinous fermentation requires much precaution; if it may be disturbed by many known causes, there are others which it is sometimes impossible to foresee or explain. It is necessary, then, to bring to this operation the most absolute care.

Acid Fermentation.—The most to be avoided of all the accidents of fermentation is, without doubt, the acid fermentation, which results in the formation of acetic acid. This is always the sequence of the vinous fermentation; it takes place when the fermented liquid is exposed to the air, under a temperature of from 20° to 35° cent. A portion of the oxygen of the air is absorbed, and aids in the formation of carbonic acid gas, the volume of which is equal to that of the oxygen which has disappeared.

The liquid becomes heated, and by degrees is rendered

turbid by a long stringy substance, which after a time is precipitated, thus restoring the transparency of the liquid. At this stage all the alcohol it contained is decomposed, and in its place is found a quantity of acetic acid which is proportional to it; from which circumstance it is concluded that the acid is formed at the expense of the alcohol.

Although chemistry cannot as yet explain in a satisfactory manner how these reactions are effected, it is known, 1st, that pure alcohol mixed with water never acidifies when exposed to the air; that it is necessary in order to convert it into vinegar that it should be in contact with a ferment or some other nitrogenous substance that will fulfil the office of one; 2d, that the presence of air and a temperature of from 20° to 35° cent. are indispensable to the fermentation of liquids containing alcohol. Hence we conclude that the ferment is in this case a cause of decomposition in the conversion of alcohol into acetic acid or vinegar.

From this statement it may be understood how important it is to prevent the access of the air to vats during the course of the vinous fermentation, and to avoid too high a temperature in the place where these vats are situated, as well as in the must when set for fermentation. The same remark is to be made in regard to the use of the ferment; while a proper quantity favors the development of the vinous fermentation, too great a dose will excite the acetic fermentation.

In order to prevent every cause that may favor the acidification of the vats, the greatest cleanliness should be observed in the distillery, and care taken to wash the empty vats as well as all the utensils with lime-water, which neutralizes the acid. It is, in fact, proven that the smallest portion of acid is a leaven which will accelerate the oxygenation of the alcohol.

The acid fermentation may also be developed under a number of exceptional circumstances. Great perturbations of the atmosphere, stormy weather, thunder, the use of fetid or stagnant water, and the foul odors which

exhale from the fermenting-rooms, are so many causes that may induce the souring of the vats.

Putrid Fermentation.—This is produced when the decomposition of the liquid passes beyond the acetic stage. The liquid then becomes viscous and turbid, disengages ammonia and deposits an earthy sediment. The rest of the liquid is nothing more than water, whose fetid and repulsive odor infects all parts of the place where this fermentation is developed.

Viscous Fermentation.—This is a spontaneous alteration which sometimes takes place in white wines of inferior quality, in common beer, beet-juice, and generally in saccharine liquids, which have been kept too long before being set to ferment. It results in rendering these liquids thick and slimy, and the transformation of the sugar and starchy matters into a kind of gummy substance.

The peculiarity of this fermentation, when developed actively, is to form in the mass of the liquid mucilaginous flocks which disturb its transparency and disengage during the chemical reaction a small quantity of carbonic acid and hydrogen gases. The light and partial foam which is formed at the surface confirms this discharge of gas, which, although small, is yet sufficient to be observed.

According to M. Payen this vitiation of fermentable liquids is attributable to the alteration of the *caseine* and other nitrogenous substances which they may contain. One quite serious cause also to which this viscous change may be attributed, is the much too feeble action of the leaven, which does not possess sufficient strength to disorganize the saccharine principle entirely.

It is to be observed that the viscous fermentation once produced in a must may be reproduced in any other saccharine liquid to which the altered must may be added; it fulfils in this case the office of a ferment.

The viscous fermentation may be easily avoided: 1st, by keeping the vats very clean, taking care to wash them with water acidulated with 5 per cent. of sul-

phuric acid of 66°; 2d, by only using good fresh yeast (*the cap*); 3d, by adding to certain must three or four thousandths of tannin or one-half of one per cent. of sulphuric acid.

Lactic Fermentation.—This accident of fermentation results in the conversion of saccharine or amylaceous substances into lactic acid. It originates like the viscous fermentation in certain albuminous or nitrogenous liquids, the fermentation of which progresses too slowly, either in consequence of using an altered ferment or in too small quantity, or by the delay in setting the vats to work.

The lactic may take place simultaneously with the vinous fermentation, and even sometimes overcome it, but most frequently it succeeds or accompanies the viscous fermentation. It is recognized by the odor and the acrid and disagreeable taste which result from it.

This accident may be prevented by the same care and precautions indicated for the viscous fermentation.

Frothing.—The evolution of carbonic acid always produces, during the fermentation of liquids, a great quantity of foam, which frequently runs over the top of the vats on to the floor of the apartment where it may occasion putrid exhalations. This accident may be prevented by sprinkling the batch from time to time by means of a broom with a solution of soft soap (500 grammes in 4 litres of water), or with a small quantity of very thick oil beaten up with water.

Sweat-House and Fermenting Vats.

After having spoken of the conditions, the phenomena and accidents of fermentation, it yet remains for us to say something in regard to the fermenting-houses and vats (vessels) destined for this operation.

Since the vinous or alcoholic fermentation may be produced during the whole year without regard to the seasons, it is necessary to have a place specially devoted to it.

The apartments in which this operation is conducted

is called by some a *cellar*, and by others a *shop*, but the proper term is *sweat-house.*

The size of the sweat-house should be in proportion to the importance of the distillery as well as to the number and capacity of the indispensable vats; it should receive as much as possible its light from the east or west, should have but little height of ceiling, and be surrounded by thick walls in order to preserve its heat. The number and size of the windows and doors should be restricted to what may be absolutely necessary, and care should be taken to cut off all air currents.

A uniform temperature being one of the first conditions of a good fermentation, a thermometer should be placed in the sweat-house to indicate the degree of heat. If the heat is not sufficiently high, it may be supplied by means of large stoves placed in the middle of the room. Distillers frequently have no sweat-house, but place their fermenting vats in the distillery itself, so as to avail themselves of the heat of the distillery or other apparatus. This method, which at first sight appears to be very economical, is highly objectionable, because it is impossible to regulate the fermentation properly. Supposing that this heat is sufficient in winter, it is incontestable that it will be too great in summer, and even sometimes in the bright days of spring and autumn. There is a loss in alcohol, which is converted into acid, which is much greater than the cost of the fuel necessary for heating the sweat-house.

As has already been said there are evolved during the vinous fermentation, considerable quantities of carbonic acid gas. This gas, the composition of which is well known, is also one of the products of combustion, and of the respiration of men and animals. It is also a constituent of many minerals, being most abundant in the natural limestones, as chalk, etc.; readily absorbed by water, it reddens litmus paper slightly, the color being restored by a gentle heat.

It is heavier than atmospheric air, nearly double the weight bulk for bulk, and may be poured from one vessel to another, extinguishes flame, and is destructive to the

life of animals compelled to breathe in an atmosphere contaminated by its presence in sufficient quantity.

We cannot recommend too great precautions against the deleterious action of this gas. On entering the vats, its presence may be readily detected by taking a lighted candle in the hand, and holding it near the bottom. The gas in consequence of its weight will occupy the lower stratum of air; if the light becomes dim, it is no longer safe to remain, and it becomes necessary to withdraw from the vessel at once, and gain free access to fresh air.

In order to keep the air of the sweat-house healthy, we should place several buckets filled with lime-water about the floor, to absorb the carbonic acid evolved; but frequently this precaution has been insufficient, and workmen have been asphyxiated on entering the building. Much risk in this matter may be obviated by making a number of openings three or four inches square on a level with the floor, to afford a means of escape to the carbonic acid gas, which, being heavier than atmospheric air, will flow off at these vents.

If a person should meet with an accident from breathing carbonic acid, he should at once be taken into the open air and caused to breathe a small quantity of ammonia (hartshorn), or, better still, chlorine gas. These remedies are often successful in cases of asphyxia from carbonic acid, yet it is better to send for a physician at once and in all cases.

The greatest cleanliness should prevail in the sweat-house; the floor should be swept every day, and, if possible, well washed with a large quantity of water. It is proper that it should be paved with bricks or tiles that will resist the action of the organic acids which form when the froth or fermented liquids (or destined for this operation) are spilled on the floor.

Occasionally the air of the sweat-house should be removed, but without varying too suddenly the temperature which is necessary for the success of the work.

The fermenting vats are generally made of oak or pine encircled by thick iron bands; their dimensions and capacity vary according to the quantity and nature of the

materials to be fermented. They should be deeper than wide, and the bottom diameter should be some inches greater than that of the top, in order to present the least surface to the action of the air, and consequently diminish the chances of acidification.

The solidity of the vats should be in proportion to their size, since the thickness of the wood has the advantage of preserving the heat and protecting the liquid from variations in the temperature of the external air. A thickness of 4 centimeters is sufficient for a vat of 25 or 30 hectolitres, and 5 centimeters for a vat of 60 or 70 hectolitres. For vats of greater capacity, the thickness should be increased in proportion.

The form of the vats is by no means a matter of indifference. Circular vats, although occupying more space than those that are square, are infinitely preferable, because they are so much better adapted to preserve the heat of their liquid contents. It is moreover readily understood that the angles of square vats will very much favor this loss of heat.

In order to avoid cooling and the loss or acidification of the alcohol, the fermenting vats ought to be hermetically closed by a cover of which two thirds may be raised at pleasure.

It is also a matter of the greatest importance to clean the fermenting vats as soon as they are emptied, and rinse them out either with slightly acidulated water (1 litre of sulphuric acid at 60° in 20 litres of water) or with lime-water. The former is used when the liquid which is drawn from the vats has not been fermented with sufficient energy, or when it contains a small proportion of sugar; the latter when the fermentation has been tumultuous or slightly acid. For this purpose, the vats should be furnished with a tap 5 centimetres from the bottom, for drawing off the liquid, and a bung in the bottom for cleaning out entirely the deposit formed during the fermentation.

An arrangement used in some distilleries under the care of the author, and which has been found very ser-

viceable, may be used with advantage for the manufacture of alcohol. (Fig. 1., Pl. VI.)

This apparatus consists of a copper coil, the diameter of which varies according to the size of the vat, placed at the bottom of the latter. This coil is connected to a pipe with two branches furnished with stopcocks; one of these conducts steam and the other cold water, according as the batch has need of being heated or cooled.

By this simple means the operation is under the control of the distiller.

CHAPTER III.

DISTILLATION.

THE object of the process of distillation is to separate liquids from each other, which are converted into vapor at different temperatures, or to isolate a volatile liquid from a fixed substance by converting it into vapor by the aid of heat, and by means of its contact with a cold body cause it to resume its liquid form by being deprived of its heat, and thus to be collected in proper receivers. It requires much care and skill.

There are many methods of applying heat in the process of distillation, and to favor the ascent of vapor according to the liquid distilled, viz., the *naked fire*, the *water bath*, *sand bath*, and *by steam*, so that the degree of heat and its manner of application may be varied with the substance to be distilled. These operations will be treated of more particularly hereafter.

Distillation is effected in apparatus, the form and arrangement of which are appropriate to the liquids or substances to be treated. Everything the earth produces may be its object and aim, but it is chiefly for the distiller of spirits and the liquorist, for flowers, plants, fruits, seeds, roots, and in fact every substance that contains an aromatic, saccharine, or amylaceous principle.

The object of the distiller of ardent spirits is to separate the alcoholic principle from any liquid that may have been previously subjected to the vinous fermentation.

The liquorist, on the contrary, only uses the process for the purpose of collecting, either by means of water or alcohol, the perfume of aromatic substances; in a word, he aromatizes liquids; he rarely distils water or alcohol separately.

Distilling Apparatus.—The apparatus used for simple or continuous distillation of spirituous liquids is commonly called *a still.*

The merit of a still consists in the harmonious arrangement of its parts, which will permit the liquid to be heated with promptness, and to be vaporized and condensed with facility; and the apparatus will be as much better as it will perform these three functions with the greatest economy of time and fuel.

The number and forms of distillatory apparatus are numerous and varied. A multitude of patents more or less valuable have been issued for improvements or for novelties which exist only on paper or in the heads of the would-be inventors. We shall only describe such as are really valuable and in actual use in distilleries of good standing.

The Simple Apparatus is rarely employed for the distillation of alcohol, because it is impossible to obtain pure products with it in a sufficiently large quantity and with sufficient economy to sustain the competition of commerce. Its use is almost entirely confined to distillers making brandy on the spot, and liquorists aromatizing the spirits for compounding their cordials.

The following are the forms of simple stills, viz:—

Still with a goose-neck,
" " moor's head,
" " column,
" of glass or retort.

The still with a *goose-neck* consists of five principal parts and five accessories.

1. The boiler or still (Fig. 1, Pl. I.) is made of tinned copper, and enters the furnace; its size varies according to its capacity. At about three-fourths of its height this piece is projected or bulged, and forms a border or flange which rests on the furnace. An opening having a *socket a*, with a screw plug *b*, is placed on this projection, and serves for the introduction of liquid to replace that which is evaporated, without arresting the distillation. The opening of the boiler is strengthened externally by a circular flange *c*, of rolled copper to support the water bath; it has two handles *d*, to facilitate the handling. A round *grate* (Fig. 2, Pl. I.) of tinned copper perforated with small holes rests near the bottom, supported by many feet *b*, two or three inches from the bottom. This grate is formed of two pieces united by hinges, and is furnished with a handle *a*, to facilitate its removal from the still.

2. The *water bath* (Fig. 3, Pl. I.) is a vessel of copper tinned inside only. It is supported by the still into which it enters. At its mouth are also two flanges, *a* and *b*, of rolled copper which fit exactly, one with the still and the other with the head. The water bath is also furnished with two handles, *c*, and a cover with a handle (Fig. 4, Pl. I.) which closes it hermetically. This cover is only used when the water bath is used for making infusions.

3. The *head* or *cap* is of copper, tinned inside only. It has the form of an inverted funnel. Its two openings are each finished with a flange of rolled copper *a* and *b*. One fitting either the water bath or still and the other the goose-neck. A hole *c*, similar to that on the still, and for the same purpose, is made at about two-thirds of the height of the cap.

4. The *goose-neck* (Fig. 6, Pl. I.) is a long copper tube bent into a semicircle, and reinforced at each end by a flange *a* and *b*, which serves to connect the still with the coil or worm. The *coupling* (Fig. 7, Pl. I.) is made of tin or copper with small flanges of copper or brass for connecting the goose-neck with the worm when the water bath is in use for distilling.

5. The *cooler* or *worm* (Fig. 8, Pl. I.) is a long pipe of block tin or tinned copper bent into a spiral *a*, the branches *b* of which are supported by the perpendicular strips *c*, of tin or copper, which are soldered to it. The upper extremity of the worm, which is connected with the goose-neck by a flange *d*, has the form of a flattened sphere *e*, and is called *lentil*. The whole is surrounded by a *slack-tub f* of copper, at the bottom of which there is a tap. The *hot water* of the cooler runs off by a *level pipe h*, which is placed at the top of this vessel. A long copper funnel (Fig. 9, Pl. I.), extending a little above the top, and descending to the bottom of the slack-tub, serves to keep up the supply of cold water. It is called the *cooling pipe*. The *beak* (Fig. 10, Pl. I.) is attached to the lower extremity of the worm to connect it with the receiver. (The *receiver* is the vessel which receives the distillate, that used by the liquorist is glass, copper, or stoneware.) The cooler is firmly supported on a mass of bricks or oaken trestles.

The apparatus with the goose-neck is generally used for the preparation or rectification of perfumed spirits.

The still with *moor's head* is composed of pieces like the last, with the exception of the *cap*, in which it differs completely. This cap (Fig. 11, Pl. I.) is made of tin or copper, and rests on the still or water bath. A long lateral pipe or *neck a*, serves to conduct the vapors into the *worm*. An opening with a neck of copper *b*, closed by a screw plug *c*, of the same metal, is placed at the top of the cap; two flanges, *d* and *e*, complete the apparatus.

The moor's head is preferred for the distillation of volatile oils and aromatic waters, as well as for Swiss absinthe.

For the distillation of aromatic waters, the *perforated water bath* (Fig. 12, Pl. I.) is used with advantage. This vessel is used to contain substances which it is desirable to subject to a higher degree of heat than can be attained by the ordinary water bath. The *perforated water bath* is not plunged into the boiling water, and the substances which it contains are subjected to the action of the steam only, thus preventing contact with the walls of the still

and the fear of having them burn and attach themselves to the sides, which sometimes happens when the contents of the still are large.

M. Soubeiran has invented the following very simple apparatus for the preparation of distilled waters by steam:—

A movable copper pipe *a* (Fig. 13, Pl. I.), in the form of a handle with a stopcock *b*, serves to conduct the steam from the still into the water-bath; a second curved copper pipe *c* is connected with it, and descending within, along the walls is bent inwards and opens near the middle of the bottom of the water bath. A perforated diaphragm *d*, supported by several feet which sustain it above the orifice of the steam-pipe, and furnished with two handles by which to introduce or remove it at will, serves to hold the plants or flowers which are to be distilled. By this system we may replace the perforated water-bath, and at the same time effect a distillation by steam, since the substances are not in direct contact with the water of the still.

The still with *column*, like the preceding, consists of a still, a cap, goose-neck, and a cooler. The column *a* (Fig. 14, Pl. I.) is the only point of difference; its height varies with the capacity of the apparatus. The extremity, which rests on the still, is closed by a fixed diaphragm *b*, pierced with a great number of holes; this supports four or five other diaphragms, *c*, fitted with handles, which rest one on the other, being each charged with a layer of plants or flowers.

A very important improvement has been added to the *column still* by Egrot, a skilful manufacturer in Paris, which consists in placing between the still and the column an intermediate piece which he calls a separator. (*Vase extractif appliqué à la distillation.*) By his process are obtained separately, but not at the same time, both the good and bad products without the latter mixing with the former.

Thus, if in the ordinary apparatus we place a *separator* (so called because it rejects all the fixed and non-

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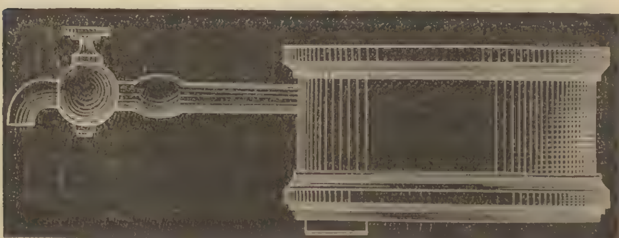
distillable products); between the still and column for flowers, it is certain, that of the steam arising from the still to pass through the flowers in the column, to exhaust them of their aroma, a small quantity will condense therein and carrying with it the color and active viscous parts of the plant (often very injurious to the operation), which instead of falling as before into the still, will now fall into the *separator* and be rejected from the apparatus.

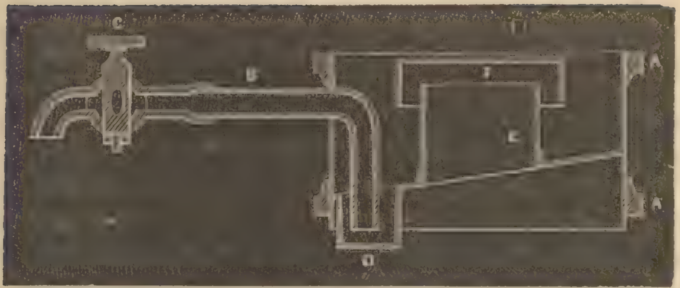
It is these viscous colored products that first fall into the still, and, under the action of repeated distillation, sometimes for an hour or two, are volatilized. They give a taste of phlegm injurious to the flavor of the distillate, or rather this turbid liquid attaches itself to the walls of the still, and detaches the tin or burns the bottom. Finally, if a distiller or perfumer finds himself pressed with his work, as happens at the period of the flower harvest, he will have the advantage with the extractor of not being compelled to change the water in his still, thereby gaining much time; since he may distil with the same liquid during the whole day, taking care only when he renews the charge to add a quantity of water equal to that drawn off during the operation; while in the present state of things, without this extractor, he is obliged to empty, rinse, and refill the still with cold water, and then wait until it has been raised to the boiling point after each operation.

Fig. 1.



The Extractor.

Fig. 2.



Section of Extractor.

A. Flanges for fitting it to the still and flower column. *B*. Waste pipe. *C*. Stopcock. *D*. Cup into which the extremity of the waste pipe dips. *E*. Cylinder through which the steam passes. *F*. Cap of the cylinder for distributing the steam uniformly.

The *retort still* is of glass, and consists of three parts (Fig. 15, Pl. I.). The *retort*, *a*; a connecting tube, *b*, which is enlarged in the middle and open at both ends; and a globe, *c*, which answers for a receiver. This very fragile apparatus is rarely used. A copper *test* still, which is similar to the simple still, varying in size from one to six litres, is generally substituted for it.

The form of distilling apparatus has undergone much change during a century, especially in regard to the cap. This piece, too, appears to be almost useless, and the less of height it has the better it is; it may, too, be replaced with advantage by a simple tube connecting the still with the worm.

The use of the cap being to contain a certain quantity of vapor, it would be more simple to conduct it at once into the worm, towards which it is attracted by the coolness of the condenser. This remark is so true that all distillers of alcohol have suppressed the cap.

Simple stills to which steam is to be applied as a means of heating should receive it in a double bottom, and not by an interior coil, as is done in stills for a continuous operation, because by this arrangement the substances to be treated may attach themselves to the surface of the

coil, and, by interfering with the transmission of heat to the liquid, retard the operation.

By the application of steam the water bath is superseded.

Continued Apparatus.

This term is applied to a form of apparatus in which the distillation progresses without intermission and without interruption, and which possesses the advantage of producing with great economy of time and fuel a large quantity of alcohol of infinitely higher degree than that obtained from the simple still. The wine is introduced in a constant stream, is deprived during its course of all its alcohol, and passes off at the other extremity in such a manner that if the liquid subjected to distillation was not susceptible of befouling the apparatus, the operation might go on indefinitely.

There are two forms of continuous apparatus, one for liquids and the other for semifluid or pasty materials.

Derosne's Apparatus.

Among the continuous apparatus, one of the most remarkable is, without contradiction, that of Cellier-Blumenthal as improved by M. Derosne, whose name it now bears. It is in use in the larger portion of the distilleries of France.

The following is a description (Figs. 1 and 2, Pl. II.) :—

A. Reservoir into which are raised the materials to be distilled. A hogshead or a barrel of any size may be substituted for the reservoir.

A^1. Bucket for regulating the flow of the liquid into the apparatus.

B. Wine-heater and condenser.

C. Distilling column. This column is built in two different modes, according to the uses for which it is intended. If for common distillation the subdivisions are made of *wire gauze* (or cloth); if it is intended more especially for the rectification, or the production of spirits of a high degree, the plates should be of solid sheet metal.

D. Upper boiler or still.

E. Lower boiler or still.

F. Furnace for heating the two boilers *D* and *E.*

G. Rectifying column.

H. Cooler or *slack-tub.*

a a. Tube for introducing the liquid to be distilled into the slack-tub *H.*

a^1 a^1. Tube by which this liquid passes from the cooler *H* to the wine-heater and condenser *B.*

a^2. A small gutter pierced with holes placed within the wine-heater for distributing uniformly the wine passing through the tubes a^1 a^1.

b b. Tube through which the liquid to be distilled leaves the wine-heater B to pass into the distilling column *C.*

b^1. Tube and stopcock connecting the lower part of the wine-heater with the tube *b b*, and serving to empty the wine-heater when the distillation is terminated.

c. Handle of a copper rod which traverses the tube a^1 a^1 and the cooler *H*, bearing at its lower extremity a dasher, by means of which the contents of the cooler may be agitated, and any deposit which may have formed at the bottom of this piece, or may obstruct the different orifices of the apparatus, can be detached.

d. Tube connecting the rectifier *G* with the coil in the wine-heater *B.*

e. Tube connecting the condensing coil of the wine-heater *B* with the coil of the cooler *H.*

f. Indicator of glass, marking the level of the liquid in the upper plate of the rectifier *G.*

f^1. Indicator of glass, for detecting the engorgement or choking of the distilling column *C.*

h. Stopcock for emptying the cooler *H.*

j. Proof bottle or jar, for testing the distillate as it flows from the coil of the cooler.

k. Opening closed by a plug and intended for removing any semifluid deposit collected in the cooler *H.*

l. Screw plug on the boiler *D*, through which if necessary liquor may be introduced when the apparatus is used for rectification.

l^1. Screw plug on the boiler *E* for the same purpose.

m m. Cover of the wine-heater *B* in which are two small open tubes for admitting air when necessary into the wine-heater, and to indicate the formation of steam therein. The cover is fitted with a water-joint.

$n\ n^1\ n^2$. Three stopcocks for returning the low wines from the coil in *B* to the plates of the rectifier *G*. These cocks correspond to different turns of the coil *B*.

$o\ o^1$. Cock and ball-float placed in the reservoir *A*. The float opens or closes the cock according to the height of the liquid in A^1.

p. Stopcock to A^1 by means of which is regulated the quantity of liquid which should flow in a given time according to the briskness of the operation.

$q\ q^1$. Goose-neck connecting the two stills *D* and *E*.

r. Glass indicator showing the level in the still *D*.

$s\ s^1$. Two cocks connected with the indicator, to be closed in case of its being broken.

t. Stopcock and pipe connecting the two stills *D* and *E*.

u. Glass indicator showing the level in *E*.

$v\ v^1$. Two cocks attached to the indicator *u*, which are to be closed in case of its being broken.

x. Stopcock for emptying the boiler *E*.

y. Valve for admitting air to the boiler *E* if necessary. There is a similar valve on the boiler *D* not shown in the drawing.

B B. Horizontal pipe for returning the low wines condensed in the coil *B*. This horizontal pipe connects with a number of small vertical pipes, each of which corresponds to a turn of the coil in the condenser *B*.

The numbers from one to sixteen indicate all the flange-joints of the apparatus; they are brought together by screw bolts.

To Commence the Operation.—Before kindling the fire under the still *E*, the different parts of the apparatus which should contain it must be filled with wine. For this purpose, the reservoir *A* being full, we open the cock *o*, then the cock *p* of the regulator A^1. The wine then flows through *a a* into the cooler *H*, fills it, and

through a^1 a^1 flows into and entirely fills the wine-heater *B*, in which it is distributed by the perforated gutter a^2.

From *B* the wine escapes by the tube *b b* to pour on to the upper plate of the distilling column *C*; from this column it descends into the first still *D*, and through the cock *t*, which is open, it passes into the still *E*.

The wine is allowed to flow from *p* until the still *E* is filled to three-fourths of its height, as may be seen by the indicator *u*; the cock *t* is then closed, the still *D* is allowed to fill in the same manner when the cock *p* is closed.

The fire is now to be started under the still *E*; the flame, after acting on this, passes under the other still *D*, and thence into the chimney.

The still *E* soon begins to boil; the steam which escapes from it passes through the curved pipe (gooseneck) *q q* to escape at the bottom of the still *D*. The liquid contained in this still *D* is also very soon set to boiling, the steam rises into *C*, traversing the plates, mounts into the rectifier *G*, and from this is conducted by *d* into the condensing coil of the wine-heater *B*; the steam which reaches this coil, surrounded by a cold liquid, is entirely condensed. The condensed product fills the return pipe *B B*, and by the tube *e* (it is supposed that the return cocks n n^1 n^2 are all closed), it passes into the coil of the cooler from which it is received in the test jar *j*.

When the brandy flows through *j*, and that part of the wine-heater *B* which is above *G* is too hot to bear the hand, we may consider the operation as started, and should open the cock *p* of the bucket A^1 to allow a continuous flow of wine into the apparatus.

To Conduct the Operation.—The apparatus being under way, the continuous stream from *p* should be regulated according to the quantity of liquid which can be distilled in an hour, and this depends on the size of the apparatus. As for *o* of *A* it will not require any attention; the ball-float which is fixed to the key of the cock will cause it to move, as the level of the liquid in

A^1 rises or falls, in such a manner as to close it before A^1 can overflow.

If it is desired to obtain brandy at 50° centigrade (*proof spirit*), the three return cocks n n^1 n^2 are ordinarily closed; when, on the contrary, a spirit of higher degree is wanted, they are opened.

In the latter event all the products of a lower degree, which are collected in coil of *B*, return upon the plates of the rectifier *G*; that only passes into the coil of *H* which has continued in the form of vapor to the extremity of the coil of *B*, and which is consequently of a decided alcoholic strength. The product which passes into *j* should be cold; if it comes over warm, or is accompanied by steam, it will be an indication that the fire under *E* is too active, if the flow from *p* is regulated according to the quantity of wine to be distilled in an hour.

When the flow of wine from the cock *p* is properly regulated it should not be disturbed so long as the operation lasts. The whole attention should be directed to the conduct of the fire, which should be increased or reduced according to the jet of brandy or spirits which flows from the proof jar *j*. If this jet is warm, it indicates too much activity of the fire; it is the same if the strength is lowered, which is caused by too much watery vapor that cannot be condensed by the quantity of cold liquid that passes into the apparatus, it is then necessary to moderate the fire.

To Empty the Stills.—At certain periods it is necessary to empty the stills *D* and *E*; this should be done without interrupting the distillation, and after being assured that the liquid is deprived of its alcohol.

When the liquid appears to be sufficiently exhausted (which is ascertained by the *test for spent liquor*, as will be explained hereafter) the wastecock *x* of the lower still is opened, and the spent liquor drawn off until what remains in the still is five or six inches deep. The cock *x* is then closed, and this still is refilled as before to three-fourths of its height, from the liquor in the upper still *D*, by opening the cock *t*. When filled to the pro-

per depth the cock t is closed, and the boiler D suffered to refill from the stream of wine which continues to flow from A^1.

This emptying causes no interruption to the distilling, the stills having kept up a constant supply of vapor. The operation is therefore continuous.

To Terminate the Operation.—When it is desired to terminate the operation, that is to say, when there is no more wine to be distilled except what remains in the different parts of the apparatus, and consequently A and A^1 are empty, it is necessary to suspend the fire for a while to empty the stills D and E, supposing that their contents are exhausted of alcohol, then to refill the stills with the contents of B by opening the cock b^1; at the same time H is emptied by means of the cock h, and the contents passed into the stills D and E by the plug l and l^1. The pieces B and H being empty are now to be filled with water, introduced from A and A^1. To prevent this water from passing into the stills D and E by the tube b b, that portion of it between the joints 5 and 6 is detached; the open end at 5 is closed by a plug, and to the end at 6 is adjusted a pipe for conveying off the waste water which flows off at this point during the operation.

The apparatus being thus prepared the heat is raised under the stills D and E, and the water is allowed to flow from A^1 through p; the water which now circulates in the two pieces B and H produces the same effect as the wine, rectifying and condensing the vapors which enter the coil B. At the end of half an hour, and when the contents of the still E appear to be sufficiently exhausted, it is emptied; and the contents of D transferred to E, the former being replenished by any wine that may remain from the contents of other parts, B and H, of the apparatus. The distillation is started anew, and so on until the whole stock of wine is disposed of.

If towards the end of the operation we do not wish too great a quantity of weak brandy and low wines, the flow of cold water should be increased, and the cock n^1 and n^2 should be opened. The low wines are then com-

pelled to return to the rectifying column, and the operation is closed when what passes through the test glass *j* ceases to exhibit any appreciable strength. All parts of the apparatus are now to be emptied. *H* is emptied by *h*, and the deposit removed through the plug hole *k*. *B* is emptied by *b*, the return pipes by o^1 o^2; *D* is emptied by *t* into *E*, and this last by *x*.

When the distillation is stopped for four or five days only, the simpler plan will be to leave the apparatus charged, and extinguish the fire when the wine ceases to flow from *A*.

To Cleanse the Apparatus.—The cleansing of the different parts of the apparatus is very important.

The distilling column is cleansed, when the plates are of wire gauze, by removing one after the other the plates which are within, and are attached to brass rods running from top to bottom. These plates are removed, washed, and scraped very easily. When the plates are of sheet metal they are movable or fixed; when movable they may be removed and cleaned one by one as for the plates of wire cloth; when fixed they are cleaned by passing steam through the column. The steam is produced by heating water in the stills *D* and *E*.

The piece *G*, in which the rectifying plates are always fixed, is to be cleansed by steam as above. This cleansing of the plates in *G* is both useful and necessary, because towards the end of the operation there accumulates in them a considerable quantity of essential oils, resulting from the substances which have been distilled. These essential oils have a very offensive taste, and a very small quantity will suffice to spoil a large quantity of spirits. It is well then when the operation is closed to pass through the whole apparatus a quantity of the steam of water to remove these essential oils as much as possible.

The cleaning of the outside of the coil in *B* is quite easy; by removing the cover *m m*, this coil may be reached by a broom or brush. The washings are drawn off by removing the plate which supports the cock b^1.

The piece *H* is cleaned by taking off the movable

cover of the cylinder, when the coil will be exposed to view, and may be reached by a swab or brush.

It is best to keep these coils *B* and *H* as clean as possible, because when these surfaces are covered with a deposit the transmission of heat is interfered with, and the apparatus works irregularly.

To prevent deposits from collecting at the bottom of *H*, and at length closing the mouth of the tube *a a*, there is placed in the midst of *H* a long brass rod called an *agitator*, the upper end of which is bent into a handle, and which has attached at the lower extremity a small disk of leather with which the liquid at the bottom of *H* is stirred from time to time, so as to distribute the deposit through the mass to be carried forward by the current.

Safeguard.—When called on to distil wines that are very rich in alcohol, as in the South of France and other warm countries, it is proper to add to the apparatus of Derosne a supplemented piece called an *evaporator* or *safeguard* (Fig. 3, Pl. II.).

This piece is placed between *B* and *H*; it consists of two concentric cylinders placed vertically, leaving an annular space between them. Along and over the surfaces of these cylinders which are exposed to the air a small quantity of water is caused to trickle, which by its evaporation will remove a large portion of heat from the alcoholic products as it passes from *B*, and before it reaches *H*. Without this arrangement the alcoholic product would be too abundant in such rich wines to be condensed by the liquid itself.

The following is a description of the different parts of the apparatus:—

b b. Inner cylinder of copper.

c c. Outer cylinder of copper.

d d. Annular space which receives the products from *B*. This space is divided by sundry partitions which cause the liquid to come in contact with every part of the surface *b b* and *c c*.

f f. Little gutter around the bottom of the *safeguard*

to collect the water which has passed over the surfaces of the cylinder.

$a^1\ a^1$. *Extension pipe* placed in the axis of the cylinder in order to elongate $a\ a^1$ of Fig. 1, to make room for the attachment of this piece.

e. Tube by which the alcoholic liquid is conducted from the coil *B* into the annular space *d d*.

e^1. Tube by which the liquid reaches the coil *H*.

x x. Circular gutter at the upper part of the safeguard from which water is caused to trickle over the surface.

It is well to cover the surface *c c* and *b b* with cotton cloths which should dip into the gutter *x x*, and which by their capillary attraction will convey to these surfaces a sufficient quantity of water for the proper working of the apparatus.

By the assistance of the supplemental apparatus the richest wines are perfectly exhausted of the alcohol they may contain.

Observations.—After this rapid survey of the general course of the distillation, in order to give a general idea of it, we now propose to go more into details on certain points which are important to the proper handling of the apparatus.

All the success of continuous distillation by means of this apparatus depends in principle upon the desired quantity of vapor which is produced in the stills *D* and *E*, being in proportion to the stream of wine that flows from A^1.

When this proportion is not as it should be, certain accidents occur during the course of the work which it is our duty to make known.

As we have said above, when the stream of wine which flows from A^1 is once fixed according to the quantity which it is desired to distil in an hour, it should not be touched any more, but the whole operation should be regulated by the fire.

The indicators *f* and f^1, applied one to the column *G* and the other to the column *C*, indicate with sufficient accuracy what is going on within the apparatus.

When the distillation is very abundant, when the degree of spirituosity diminishes very rapidly, and the liquid is seen to rise in the indicator f^1 beyond its middle point, we may conclude that there is too much watery vapor produced by *E*, and the fire must be checked by closing the register of the furnace.

If the liquid in the indicator *f* becomes discolored it is necessary to reduce the fire at once, unless we would see the liquid to be distilled pass into *B*, and come over through *j*, mixed with the product of distillation. These effects are easy to be understood; the steam which is generated in *D* and *E*, being too abundant and having too much tension, interferes with the descent of the wine by the column *C*; the wine accumulates in the plates of this column, and rises successively into those of the rectifier *G*, mixes with the low wines, colors them, and risks passing into the condensing coil of the wine-heater *B*, and thence into the coil of the cooler *H*. This is what is announced by the indicator *f* and f^1.

If it happens, in consequence of insufficient attention, that there should be too great a disturbance in this way in the working of the apparatus, we may, in order to establish the equilibrium more promptly, increase the stream of wine from A^1, at the same time that the fire is reduced; this will cause a more prompt condensation of the vapors, but this expedient should be resorted to only in case of a serious accident.

The distillate should always reach the test jar *j* cold; if it comes over warm, it shows that the fire is too active.

It is on the operation of the return cocks n n^1 n^2 that is based the whole system of rectification by this apparatus, which enables us to procure even from the poorest materials spirits of the highest proof.

For a proper comprehension of the effect of these return cocks, it is necessary to conceive that the products are richer in spirit as the part of the coil in which the condensation takes place is remote from *d*.

In fact, the vapor which passes into the coil by *d* is a mixture of the vapors of water and alcohol in certain proportions; the vapor of water is more easily condensed

than the vapor of alcohol; since, in order that the former may be reduced to the form of water, it is sufficient to have the cooling liquid a little below 100° C., while the alcohol continues in a state of vapor until the temperature of the surrounding liquid is reduced to 40° C.

It is understood, then, that when the vapor, a mixture of alcohol and water, passes into the condensing coil *B* a portion of the watery vapor is condensed, and that which passes further on is more highly charged with alcohol. In the next turn of the coil another portion of vapor of water is condensed, thus rendering the aëriform product still more alcoholic, and so on until by advancing towards *e* the vapor is so far cooled down that the vapor of alcohol is itself condensed.

We observe by this that the further it advances in the condensing coil, from *d* towards *e*, the stronger will be the alcoholic product which condenses therein. This being taken for granted, since all the product that condenses in the different turns of coil *B* pass into the horizontal return pipe *B B*, by means of the small vertical tubes which correspond to them, we see that, if by opening the return cock *n* we cause to return into the rectifier *G* all that has been condensed in the first part of the coil from *d* to *n*, we shall receive in the proof-bottle *j* a stronger product than we should have obtained if the three cocks had been closed, and the whole of the product had passed through the cooler *H*. If we open n^1 we shall have a still stronger product, and by opening n^2 we shall only have what is condensed in the last turn of the coil of *B*, and consequently this will be the strongest spirit that can be produced by the apparatus.

The office of the rectifier *G* is also easy of comprehension. This rectifier is divided internally by plates superposed one above the other, which each retain a portion of the low wines which pass through the return pipe from the coil of *B*. The alcoholic vapor which rises from *C* plunges successively into each of these plates, commencing at the lower and passing on to the upper one. This vapor is enriched by plunging into the already strongly alcoholized liquid returned from the

coil, and is enriched more and more, because the more spirituous product is returned to the upper plates; for it may be seen that the product from the cocks n^1 n^2 are emptied into a part of the rectifier above that from the cock *n*.

The proof bottle *j* is an instrument through which the distillate passes previous to being received in vessels destined to hold it. Into this proof bottle is plunged an alcoholmetre, which indicates at each moment of the operation, the alcoholic strength (or degree) of the liquid which flows from ths coil *H*. By inspecting this instrument, the workman is guided in his labor according to the degree of strength required.

Closing Remarks in regard to the Apparatus of Derosne.—To prevent all leakage, the joints of this apparatus are made by interposing between the two surfaces, a circular washer of cardboard smeared with some greasy substance or a mixture of red and whitelead ground in oil, and brought together with clasps or bolts.

The various joints which are not made as above, but by fitting into a socket such as the fittings of the glass indicators, &c., should be luted very carefully. This lute is prepared by mixing red lead with the ordinary white paint, which is whitelead well ground in a drying oil, so as to form a paste having the consistency of glazier's putty. Bands or strips of cloth greased with this paste are used to cover the joints.

A good lute is made by mixing equal parts of wheat flour and Spanish whiting in fine powder with the white of egg. Strips of cloth dipped in this mixture are to be applied to the joints as above.

In setting the glass indicators, care must be taken not to close the orifices of the pipes, which connect them with the interior of the apparatus, which will happen if the tubes are too long, for then the liquid cannot have access to the tubes, and the indicator will be useless.

The first product which flows from a new apparatus has a taste of copper and resin; this soon ceases. If this is not thrown away, it should be put aside to be mixed with the wine or for rectification.

It is always important to commence, as was indicated when describing the process for starting the operation, by filling the wine-heater and cooler with the liquid to be distilled, before raising the fire under the stills, and sending steam through the different parts of the apparatus, for if we commence by raising the steam and turn on cold water, there is risk of crushing the apparatus under the weight of the atmospheric pressure in consequence of the formation of a vacuum.

When the operation is started, care must be taken not to allow cold liquid to flow into the stills when the ebullition has commenced, for fear of a similar accident. Care must be taken during the first heating to arrest the flow of wine into the stills, by closing the cock of the regulating tub, until the wine-heater is too hot for the hand. When the liquid is heated to this point, we may without hesitation allow it to flow into the distilling column; there is no longer any risk from the condensation of the steam, and the operation may go on continuously.

In starting the operation when the steam begins to pass from the first still into the second, by means of the goose-neck, a loud noise is produced, sounding like the blow of a hammer in the second still. The noise is occasioned by the instantaneous condensation of the steam as it passes from the first still into the cold or only tepid liquid in the second, thus forming a kind of vacuum. This noise will continue until the liquid in the second still has acquired a sufficiently high temperature. The steam produces a similar noise, only much feebler, as it passes over each division of the distilling column.

Egrot's New Apparatus for Continuous Distillation.

PLATE III.

The difficulties to be avoided and the care to be observed, in order to obtain good results by means of the distilling apparatus used at the present time, have induced M. Egrot to seek to improve this state of things. After many efforts crowned with success, this skilful

artificer has succeeded in constructing a new apparatus which fulfils all the required conditions. *Simplicity of use and management, richness in degree, facility of setting up and cleaning, economy of fuel, space, and transportation, and of moderate price.*

The theory of this new apparatus is based on one of the most simple principles, that of the direct or multiplied contact of vapor, under a feeble pressure, with the wine to be distilled. By this means, acting on a small quantity of wine, we obtain a rapid ebullition; and the separation of the alcohol is very promptly effected. Producing its effects in a small space, and over a great extent of surface, the apparatus exhibits the best conditions for economizing fuel; on the other hand, the feeble pressure existing in the column by reason of the small number of plates of which it is composed affords but little resistance to the passage of the alcoholic vapors, and the distillation is effected in a most simple and easy manner.

The apparatus is not liable to the accidents which so frequently occur in those with a high column. The distiller charged with its management need not fear irregularities in the distillation in spite of too active a heat when using the open fire, or from too great a flow of steam when this agent is used.

If there exists a stumbling-block or hindrance to distillation, it is without contradiction when the apparatus *primes*, that is to say, when the wine subjected to distillation comes over mixed with the alcohol, and flows from the pipe which should ordinarily only deliver the latter. This inconvenience takes place in a great number of apparatuses at the least blast of the fire, or under the influence of a little too much wine. We are compelled then to arrest the operation to interrupt the distilling, and for this purpose smother the fire, draw off a part of the wine not exhausted, and rearrange the apparatus as before in a proper state for working properly. This requires more or less time, which, if the accident is repeated, occasions delays in the operation,

and leads to a disturbance of the general workings of a distillery.

In the new apparatus of M. Egrot all these difficulties have been obviated. If there is an excess of heat produced either by the open fire or by steam, the distillate will be of lower degree than usual, but the apparatus does not *prime;* we can then, when this lowering of the strength is observed, at once re-establish the equilibrium, disturbed for the moment, and consequently avoid all those annoyances and delays we have just pointed out.

With this apparatus may be distilled all wines and fermented liquids derived from any source, and semifluid materials when the apparatus is of sufficient size.

The product obtained, whether as brandy or alcohol, is peculiarly fine. The apparatus distilling from 10 to 300 hectolitres may be heated either by steam or open fire; those which exceed these dimensions must be heated by steam.

All the pieces of this apparatus are of copper, the flush-couplings of iron, the cocks and connecting-nuts and pipes of bronze.

Description of the Apparatus.—This new apparatus is composed of the following parts:—

a. Copper still.

b. Siphon for the continuous exit of waste liquor.

c. Waste pipe for completely emptying the still when necessary.

d. Opening for cleaning the boiler, closed by a plug.

e, *f*, *g*, *h*. Brickwork of the furnace.

i. Fireplace.

j. Grate.

k. Ash-pit.

l. Flue. *Note*—when steam is used—the furnace is replaced by brickwork.

A. Distilling column composed of plates for continuous distilling.

B. Cap covering the last distilling plate and supporting the rectifying column.

D. Rectifying column.

E. Goose-neck conducting the alcoholic vapor to the rectifying coil of the wine-heater.

F. Jacket containing the rectifying coil, and acting as wine-heater.

G. Jacket inclosing the cooling worm.

I. Exit of the cooling worm.

J. Funnel to receive the wine and convey it to the bottom of the wine-heater.

K. Pipe to convey the wine from the wine-heater to the first plate.

N. Pipes and cocks for returning the low wines into the rectifying column *D.*

R. Regulating bucket.

S. Ball float.

T. Regulating cock with an index to guide the distiller.

U. Pipe to convey the spirits to the proof bottle.

V. Proof bottle—improved pattern.

Y. Pump.

Z. Wine Vat.

To Work the Apparatus.—To put this apparatus in operation it is sufficient to fill the vat *Z* with wine or other liquor that is to be distilled, by means of the pump *Y*, then open the cock *T*, which permits the wine to flow into the cooler *G*, the wine-heater *F*, and the distilling plates *A*, taking care that the wine does not run into the still *a*.

When the apparatus is to work over the naked fire, the still *a* is filled with water* by introducing it through the plug *d*, and the fire started; the water of the still begins to boil, and the steam which it furnishes passes through each of the distilling plates *A*, depriving their contents of its alcohol; from this the alcoholic vapors pass into the rectifying column *D*, where they deposit their impurities, then pass by the tube *E* into the rectifying coil contained in the jacket *F*; finally the alco-

* When the apparatus is heated by steam from a boiler, the precaution of commencing the distillation with water is unnecessary; the still may be filled with wine as the other parts of the apparatus.

holic vapor, after being more or less rectified in the coil according to the will of the manager, passes into the cooling coil contained in the jacket *G*, to pass out in a liquid state at *I*, and to be received in the proof bottle *V*, in which there is an alcoholmeter to mark the strength or degree of the brandy or alcohol as it comes over.

The wine moves in the opposite direction. It is introduced into the apparatus by opening the index cock *T*; the funnel *J* which receives it conducts it to the bottom of the jacket *G*, pushing forward the liquid contained in the jackets *G* and *F*; it leaves the upper part of the wine-heater by the tube *K*, which directs it to the first distilling plate of *A*, when, after having circulated in the galleries, it is spread in succession over the plates below, then falls into the boiler, whence it escapes by the waste siphon *b* as spent liquor, completely exhausted of alcohol.

The wine in traversing the interior galleries of which the plates *A* are composed, comes in contact with a great number of small pipes, which forcibly distribute the vapor in the course of the distillation, and agitate the wine without ceasing, thus causing the latter to be easily freed from the alcohol it contains; it is also to this new arrangement that the good quality and delicacy of the products obtained from this apparatus are due.

This fact is easy of explanation if it is remembered that the wine to be completely exhausted does not remain in the apparatus longer than ten or fifteen minutes; it is subjected for a very short time to the action of the heat, and the empyreumatic oils and bad flavor can neither be formed nor pass over with the distillate.

The principal advantages of this apparatus are:—

1. *Facility of setting up—Economy of Removal and Transportation.*—The small size and great simplicity of construction of which it admits renders the setting up very easy.

The adjustment of the two principal pieces, the still and the condensing wine-heater, is very convenient, both being placed vertically on a foundation easily constructed;

the connecting pipes being few in number are readily fitted. Its small size requires but little space, and consequently the cost of packing is relatively less, and the expense of carriage trifling if to be moved to a distance.

2. *Remarkable Economy of Fuel.*—In consequence of its small dimensions, it affords less surface and does not give out as sheer loss the caloric previously absorbed by distillation. It is a fact, that the larger the apparatus, the greater will be the expense of fuel necessary to work it. The economy of fuel lies too in the peculiar construction of the plates. During the course of the distillation, the vapor being forcibly distributed, is brought in direct contact with the circulating wine, which it agitates freely, from which results a forced ebullition, setting free all the alcohol contained in the liquid.

3. *Facility of Use.*—Being composed of only three or five plates, according to the alcoholic richness of the wine, the distillation is effected without pressure, consequently without disturbance, and without fear that the apparatus will *prime*, that is to say, the wine raised by an accumulation of steam or foam will not pass over instead of the alcohol. This stumbling-block in most apparatuses is completely avoided in this; there never being a sufficient quantity of wine in course of distillation, and it is too rapidly exhausted for foam to be formed and obstruct the channels.

4. *Richness in Degree.*—By reason of the rectifying column placed on the distilling column, and the return of the low wines, the alcoholic degree may acquire a remarkable strength, and the spirit come over at from 70 to 92 degrees, especially when wines are operated on. Moreover, the alcoholic strength is under control and may be fixed at the option of the distiller.

5. *Moderate Price.*—A question of prime importance is the cost, which is considerably reduced and the difference is greatest for the apparatus of large dimensions. This difference in price naturally depends on the smallness of size which requires less material, without in any degree affecting the solidity of the parts.

6. *Simplicity of Cleaning.*—In order that an apparatus may be well suited for use, it should be easy to clean. In this, if of small dimensions, it is sufficient to remove the three or five plates, and if of large dimensions, to open the manholes and wash out the interior thoroughly. If this cleaning is repeated every two months, the apparatus will be in the best condition to furnish excellent products. The wine-heater has at its lower extremity a screw plug, which facilitates the removal of any deposit collected at the bottom. The still has also an opening *d* through which it may be washed out; all the coils are mounted in their jackets by joints, so that in the event of cleansing of these coils, as when it is desired to remove the tartrous crust which surrounds them and interferes with the action of the coolers, they may be removed from their jackets without having recourse to the tinner and his solder.

This apparatus may be rendered complete by the addition of the following pieces:—

1. In some countries, and particularly in Spain, where very rich wines are distilled, it is common to obtain, at the first distillation, spirits of a very high degree, exceeding 90° cent. In this event it is necessary to add a rectifying cap, which should surmount the rectifying column, which, by its peculiar arrangement, refines and increases the strength of the spirits.

2. When wines or other fermented liquors which are intended for the still, are highly spirituous, *i. e.*, exceed ten or twelve per cent. of alcohol, it may become necessary to use an additional plate, to insure the complete exhaustion of the waste liquor.

3. A pump is indispensable for raising the liquor into the vat. The Eureka Pump Company of New York, under the management of a highly intelligent and accomplished superintendent, manufacture a pump, either of iron or bronze, which is peculiarly well adapted for the use of the distiller.

By the particular arrangement of the valves it cannot be obstructed even by solid substances of much greater size than would be found in a distiller's vats. A

child can work it so as to throw a very large and abundant stream. It is invaluable for industrial purposes, as well as in case of fire.

The French manufacturer furnishes this apparatus of twelve different sizes, the smallest of a capacity of 800 litres in twenty-four hours, the largest 100,000 litres in the same time.

Belgian Apparatus.

This apparatus, the arrangement of which is due to Cellier-Blumenthal, is used in the large alcohol factories; it presents the advantage of exhausting the liquor promptly, of receiving and discharging at the same time a given quantity, of occupying but little space, and of being easily controlled. Unlike the apparatus of Derosne, it has no return pipes; the alcoholic vapors in passing over the plates are refined, and change more and more, and pass into the proof bottle, marking 50° or 60° on the alcoholmeter.

The following is a description of the apparatus, as shown in Fig. 1, Pl. IV.

A. Distilling column of copper, sheet or cast iron, consisting of eighteen sections, each containing a plate. (See arrangement of these plates, Figs. 2 and 3, Pl. IV.)

B. Goose-neck conveying the alcoholic vapor into the *forwarding tub* or wine-heater.

C C^1. Forwarding tub or wine-heater divided into two parts, each inclosing a coil.

D. Cooler also inclosing a coil, and condensing the vapors by the aid of cold water.

E. Stopcock for turning steam into the apparatus where it escapes directly into the liquor.

F. Discharge cock or level pipe for the spent liquor.

G. Pipe to conduct the warm liquor from the upper part of the wine-heater into the distilling column.

H. Feed pipe, for delivering the cold liquor at the bottom of the wine-heater.

I. Bent pipe, connecting the coils in the two divisions of the wine-heater.

J. Bent pipe, connecting the coil of the wine-heater with that of the cooler.

K. Point of entrance for cold water into the cooler.

L. Point of exit for warm water from the cooler.

M. Extremity of the coil from which the distillate is received.

To Set going and Use the Belgian Apparatus.—Let the wine run through the feed pipe *H* until it fills the two divisions of the wine-heater, then by passing through the tube *C* descends into the distilling column, *A*. When the liquor has reached the top of the level pipe *F*, which is known by means of a glass indicator placed at the bottom of the apparatus, the cock of delivery is to be closed, and the cooler *D* filled with cold water; it is necessary to leave open the cock of the level pipe *F* while the wine is falling through the column, to allow the escape of the air, which is pushed before the descending liquor.

When these arrangements are completed, close the level cock *F*, and open the steam cock *E*. This cock is in communication with a steam generator, by means of a copper pipe; the steam is discharged directly into the liquor, and sets it to boiling; the plates are heated in succession, the alcoholic vapors traverse them, being charged more and more, and pass through the goose-neck *B*, into the wine-heater CC^1, where they are partially condensed, then descend into the coil of the cooler *D*, where the condensation is finally completed. As soon as the spirit begins to flow from the pipe *M*, turn on wine through the feed pipe, in a quantity proportional to the capacity of the still, and open the cock *F* so as to permit the spent liquor to escape through the level pipe. The wine, after a sojourn in the wine-heater, becomes heated, circulates in each of the plates in succession, falling from one to the other, and reaches the bottom of the still completely exhausted, thence it flows of itself, and continuously through the level pipe *F*. From this point care must be taken to keep up an equable temperature, in order to maintain perfect regularity in the progress of the distillation.

A Belgian still, five meters high and twenty meters in diameter, will distil from 800 to 1000 hectolitres of fermented liquor in twenty-four hours.

Apparatus for Distilling Pasty or Semifluid Materials.

The invention of this apparatus is also due to Cellier-Blumenthal. With it may be distilled raw potatoes, artichokes, grain, &c. As may be seen, Figs. 4 and 5, Pl. IV., it differs but little, very little, from the preceding, which, by the addition of an agitator, can be used for distilling pasty liquids, and replace this, of which the following is a description :—

A. Distilling column, consisting of twelve sections, each containing a plate.

B. Forwarding tub, or wine-heater, for heating the materials to be distilled, by means of the alcoholic vapor from the distilling column, this vessel inclosing a coil as well as an agitator, which is set in motion by gearing qq^1 fixed on the shafts *p* and *r*.

C. Cooler for water, inclosing a large coil.

D. Pump for feeding the wine-heater.

e. Spherical foam arrester, containing a diaphragm on which the foam is broken in the event of any sudden increase of the heat.

f. Goose-neck, conducting the alcoholic vapor into the coil of the wine-heater.

g. Connecting pipe between the coil of the wine-heater and the water-cooler.

h. Discharge pipe for the distillate.

i. Proof bottle, covered by the glass bell *j*, in which is placed an alcoholmeter for testing the strength of the spirit as it flows from the still.

k. Funnel and pipe, to receive the materials from the pump *D*, and deliver them into the wine-heater.

l. Tube, for conveying the materials to be distilled, from the wine-heater into the still.

m. Steam pipe, for heating the apparatus.

n. Pipe to supply cold water to the slack tub *C*.

o. Level pipe, for carrying off hot water from the cooler.

p. Vertical shaft of the agitator, of iron, for forcibly stirring the materials in the wine-heater, to prevent them from settling on the bottom of the vessel.

qq^1. Gearing, by which the motion of the shaft *r* is transmitted to the vertical shaft *p*.

r–s. Crank, for communicating motion to the pump *D*, and the agitation of the vat *C*.

t. Large screw plugs, for cleaning the plates of the distilling columns.

u. Pipes, for pouring the materials from one plate upon the next, when the level rises above the level of these pipes.

v. Spherical caps for discharging the alcoholic vapors into the materials contained in the plates.

x. Tubes, through which the steam passes from one plate to the other; these tubes may be screwed in for convenience of moving at will.

y. Basin, for receiving the exhausted materials. This piece is so arranged that the steam passes freely between it and the walls of the column.

z. First plunging or safety pipe, for the discharge of the exhausted materials.

z^1. Second safety pipe, for discharging the exhausted mass from the still.

Method of Using the Apparatus.—The semifluid matters are transferred to the vat *C*, by means of the pump *D*, at the same time the agitator is set in motion. When the forwarding tub (wine-heater) is full, the semifluid mass passes through the tube *l*, spreads over the plates of distilling column *A*, and after passing through the pipes *u*, falls into the basin *y*, and thence into the bottom of the still. When this arrangement is complete, the steam is turned on by the pipe *m*. This steam being *direct*, that is to say, moist, there is very soon a sufficient quantity of water produced by the condensation, to prevent the mass from being too thick. As soon as the ebullition is established, the alcoholic vapor passes successively into each plate through the tubes with spherical caps *v*, and

by its action on the liquid, it is more and more charged with alcohol. After having traversed the column, the vapor is passed into the coil of the heater B, through the goose-neck *f*, where it gives off most of its heat to the material contained in the vat, and from this passes into the cooling coil C, where it is condensed into a liquid.

When the spirit begins to flow, the pump is again set in motion, to maintain the supply of materials. The more solid parts are kept in suspension in the heating vat, by means of the agitator *p*, and fall on the plates of the still. The alcoholic vapors thin the mass more and more, in proportion as it passes to the lower plates.

When the mass arrives at the basin *y*, it is completely exhausted, and discharges itself through the safety pipes z and z^1.

Rectifying Apparatus.

There is scarcely any difference of form between this and Derosne's still. Indeed, the latter will answer perfectly for rectifying, by suppressing the first boiler, re placing the plates of wire cloth by solid plates. Nevertheless, manufacturing and country distillers prefer an apparatus specially adapted to rectification.

The following is a description of the apparatus exhibited in Figs. 1 and 2, Pl. V.

A. Still.

B. Column, containing twenty plates *a*, and twenty-four level pipes *b*.

C and *D*. Small cap and pipe, to conduct the alcoholic vapors into the condenser.

E. Condenser, inclosing a horizontal coil *c*, which is preceded by the lenticular vessels d d^1, each containing a vertical partition.

F. Pipe, conducting the vapors into the cooler.

G. Cooler, containing a vertical coil.

H. External return pipe, serving to convey the condensed vapors to the plates of the column (another return pipe is placed within the condenser, and communi-

cates with the external pipe, by means of the little tube $g.g^1$).

I. Cock on the return pipe, by which it may be ascertained if the return of the condensed spirit goes on properly.

J and *K.* Pipe and cock, by which the water of the condenser may be emptied on the plates.

L and *M.* Cap and pipe, through which the water passes from the cooler into the condenser.

N. Level pipe, through which the hot water flows from the condenser.

O. Waste cock to the cooler.

P, P^1. Air holes.

Q. Waste cock of the still.

R. Glass indicator, to mark the level of the liquid in the still.

S S^1. Cocks of the indicator.

T. Gauge showing the pressure existing in the still.

U. Man-hole for cleaning out the still.

V. Cock for filling the still with the low wines to be rectified.

The method of starting and using this still will be explained under the head of rectification.

Apparatus for Distilling Rum.

The arrangement of this still is due to M. Egrot. Its use and management are simple and easy, and it is much used in the French and English colonies and in Cuba.

The apparatus is made of tinned copper, and consists of the following pieces, Fig. 3, Plate V.

A. Still which is to be filled to two-thirds.

B. Rectifying cap through which the alcoholic vapors pass, and where they lose a portion of their essential oils.

C. Wine-heater, or forwarding vat, inclosing a coil through which the vapors pass into the cooler by the pipe *h*.

D. Cooler, containing a coil. (There is nothing peculiar about this piece.)

d. Waste pipe and cock to the still.

e. Goose-neck, conducting the vapors from the rectifying cap to the coil of the forwarding vat.

f. Pipe and cock for emptying the contents of the wine-heater into the still at the termination of the operation.

g. Return pipe.

h. Pipe connecting the coil.

i. Mouth of the cooling coil from which the spirits pass off.

k. Funnel through which cold water is conveyed to the bottom of the cooler.

l. Level pipe by which the hot water escapes from the cooler, as it is replaced by cold water from the funnel.

m. Pipe and cock for conveying cold water into the cap *B*. (The water passes first through a small funnel pierced with holes which surround the pipe *e*, and after passing through a spiral (*snail*), contained in the cap, passes off at a temperature of about 60° through the level pipe *n*.)

As a general thing in rum factories, the wine-heater is omitted; only the more intelligent planters use it. By this means they take advantage of a part of the heat arising from the distillation, and by this, much hasten the heating of the liquid to be distilled.

The use and management of this apparatus are the same as for the simple still. Care should be taken to keep up the supply of cold water to the cooler, in order to prevent the rum from passing over in the form of vapor.

A description of several other stills for special products and purposes will be given in the body of the work.

Machines and Utensils Necessary for a Distillery.

The machines and utensils for preparing vegetable substances for the vinous fermentation, or necessary for the distillation of alcohol, are of various kinds, according to the nature of the substances to be treated. We shall rapidly pass in review those that are in some measure indispensable to the greater part of these preparations.

The Washer.—Is used for removing dirt, &c., from the roots and tubers employed by the distiller.

The Rasp.—The character of this instrument is of very great importance in a distillery, for it may cause a variation of a fifth in the product. The machine should combine rapidity of motion with a perfect trituration.

The Root Cutter or Slicer.—This instrument is used for slicing roots which are to be treated by maceration. A root cutter, by whatsoever power it is driven, should have a velocity of 130 or 150 revolutions a minute to do its work satisfactorily and well.

The Hydraulic Press.—For extracting thin juice from the pulp of roots, or wine from the weared of the grape, cider from pumice, &c.; it has, by its superior properties, superseded almost all other means of obtaining pressure among intelligent manufacturers.

The Steam Press.—This press is but little used except in large distilleries. It is very expeditious, and considerably hastens the work, but it is necessary that the sacks, which have been submitted to its action, should also be subjected to the action of the hydraulic press; for the pressure by steam is made almost instantaneously, and we can obtain by it only 60 or 65 per cent. of juice from rasped beets.

The Vat for the Conversion of Starch into Sugar.—When starchy materials are treated on a large scale, solid oaken vats, Fig. 2, Pl. VI., are used from 8 to 10 centimeters thick, and of sufficient capacity to contain 125 hectolitres up to the line a, a^1. Vats with much thinner walls may be used, but it is necessary to line them with sheet lead to obviate the carbonizing effect of the sulphuric acid.

b, b^1, b^2. Lead pipe bent into a circle near the bottom of the vat. The circular portion, b^1, b^2, is split at short distances to allow the steam to escape into the liquid contents of the vat. This pipe is connected to a copper steam pipe.

d. Funnel through which the dissolved starch is added in small quantities at a time.

e. Flue for conducting the vapors from the vat to the stack of the chimney.

f. Man-hole through which lime is admitted for the saturation of the sulphuric acid, and for removing the deposit, and washing the vat.

g. Cock placed 15 centimeters from the bottom of the vat for drawing off the clear liquid only.

h. Plug placed at the bottom for emptying the vat entirely.

Macerators.—The process of extracting the saccharine principle from vegetable substances is effected by many arrangements of apparatus of more or less value. In speaking of the manufacture of alcohol from the beet, we shall describe those processes only which appear to be best adapted to the wants of the distillery.

Elevator.—This name is applied to a small iron cylinder shaped like a boiler, generally used in sugar factories and refineries for raising the juice or syrup to the different stories of the building, by means of steam pressure. The elevator replaces the pump very advantageously; a few minutes are sufficient for raising 10 hectolitres to a height of 20 or 25 meters, and even more. Its use is a source of economy and expedition; we therefore employ it constantly, even in small country distilleries where steam is used.

The following is a description of this interesting and remarkably simple apparatus, with its accompanying tank, Fig. 3 and 4, Pl. VI.

A. Elevator.—Cylinder of iron plate, having hemispherical heads, and capable of bearing the same pressure as the steam generator. It should be tested for the same number of atmospheres.

B. Tank for receiving the liquid to be raised.

b. Cock for opening communication between the elevator *A* and tank *B*.

c. Cock for ascertaining when there is a sufficient quantity of liquid in the elevator.

d. Steam cock.

f. Cock for the escape of air, to facilitate the entrance of the liquid.

g. Three-way cock, by which the liquid may be directed to different places.

h. Tube rising from the bottom of the elevator for conveying the liquid to the three-way cock in its ascent.

i. Man-hole for repairs and cleaning.

To Use the Apparatus.—First open the air cock *f*, to allow the air to escape, then open the cock *b*, in order that the liquid may flow into the elevator. When the liquid rises to the level of the cock *c*, close the cocks *f* and *b*, turn the key of the three-way cock *g* towards the pipe by which the liquid is to be raised, and open the steam cock *d*; the steam will fill the vacant space and press on the surface of the liquid. This will yield and rise promptly by the inner tube *h*, and pass to its destination without leaving the smallest quantity in the apparatus. The progress of the operation may be followed up by placing the hand on the pipe through which the liquid is passing. As soon as the heat becomes too great to be borne, it is certain that there is no more liquid in the elevator.

Another method is sometimes adopted for using the elevator, as follows: Open the three-way cock *g* upon any pipe, taking care to close the cocks *b*, *c*, and *f*; open the air cock *d*, in order that the steam may completely expel the air from the vessel; this may be known when the cock by which the air is escaping is too hot to bear the hand; at this moment close first the cock *g*, then *d*, the steam will condense and cause a vacuum in the apparatus; then, after two or three minutes, open the cock *b* only; the liquid is drawn rapidly into the elevator; at this stage close the cock *b*, turn the key towards the pipe through which the liquid is to be raised, and open the cock *d*.

When through inattention the elevator is entirely filled with liquid, it is impossible to make it operate; the steam, by the loud *clapping* produced by its condensation, announces this accident, which is easy enough to remedy. For this purpose, open the cock *b*, when the steam presses the liquid back into the tank *B*, and, as soon as a proper quantity has been drawn off, close the cock *b*;

there being now space enough for the steam to press properly on the liquid, the operation will go on properly.

Pumps.—Two kinds of pumps are used in distilleries; one for liquids, when there is no elevator, and the other for semi-fluid materials.

The former should be a forcing and suction pump, and should occupy but little space. The Eureka pump made in New York, besides combining these properties, is cheap, and requires but little force to work it.

The second, called the movable tube pump, has the advantage of having no piston, and not being liable to choke; it raises pasty substances as well as hot or cold liquids. There is in this pump no cause of derangement, the only part which must be cared for is the piece of leather that is in the movable tube: all delays are prevented by having extra leathers in case of accident.

Filters.—It frequently happens that clear liquids have to be separated from deposits which have formed, or from substances held in suspension; it is necessary that the distiller should have a number of filters at hand. They may be made of cloth stretched on frames; but those which appear to be most convenient consist of large baskets lined with woollen cloth. The liquid to be filtered is poured into these lined baskets. The liquid passes through while the grosser matters are retained.

Besides the machines and utensils just described, there are many others which are necessary to the distiller, and which it is only necessary to record by name. They are, for the wine distiller, *grape-pickers*, *pestles*, and *presses;* for the grain distiller *vats for steeping*, and *germinating-kilns*, *mills for crushing or grinding grain*, *vats with a double bottom*, and *boilers for starch*, *flour*, *&c.*

Some utensils of daily use are indispensable, as *wooden rakes*, *shovels* and *skimmers*, *iron forks*, *siphons of tin*, *lead*, *or gutta percha*, *spirit-pumps*, *wine-testers*, *tin pans and measures*, wooden buckets, *faucets of various sizes*, large funnels of *tin and wood*, *deep wooden tubs*, *beaters*, *tap-borers*, &c.

6

CHAPTER IV.

ON THE APPLICATION OF HEAT TO DISTILLATION.

HEAT is the principal agent of distillation. The general laws regulating its action on material substances constitute an interesting study, for which the reader is referred to any of the scientific books on the subject.* It is sufficient to say here that it is capable of being transmitted by conduction through the substance of bodies which are called good or bad conductors according to the facility of the transit, and that it passes from one body to another either by contact or through the surrounding atmosphere by radiation. There is a tendency among all bodies to acquire an equilibrium of heat by giving it off, or by absorbing it, as the case may be.

By its power of penetration it overcomes the cohesive force which exists between the atoms of matter. By its accumulation in the body of a substance these effects are shown by the dilatation, which progresses until the solid becomes a liquid, and the liquid is finally converted into gas or vapor. By the abstraction of heat contrary effects are produced. This may be seen in the example of water, which is so readily presented under the three forms of ice, water, and steam, as increase or diminution of this imponderable force may determine.

The following table will exhibit the boiling point of different liquids in degrees of the centigrade thermometer:—

Sulphuric ether	35°.5	Syrup of sugar	105°
Pure alcohol	78°.4	Water saturated with table salt	106°
Alcohol of 90° strength	80°.1	Water saturated with nitre	114°
" 85° "	81°.1	Oil of turpentine	155°
" 59° "	85°.8	Sulphuric acid	305°
" 45° "	88°.9	Linseed oil	315°
Pure water	100°	Mercury	350°

* See particularly *Box, A Practical Treatise on Heat*. Philadelphia: H. C. Baird.

We have already said that bodies have a tendency to acquire an equilibrium of heat, and that the transfer from one body to another is made by contact. The greater the number of points of contact the more rapid will it be effected.

It is, therefore, easy to conceive that in subjecting a liquid to the action of caloric in a still, it will be heated more rapidly in proportion to the number of points of contact presented to the source of heat and to the conducting power of the material of which this vessel is made. For this reason a still should be broad and shallow if it is destined to evaporate its contents rapidly.

Heat for practical purposes is derived from the combustion of various kinds of fuel. Much of the useful effect to be derived from the combustion depends on the construction of the furnace where it is effected, and in which the heat is applied to the different bodies to be heated.

The heat for reducing liquids to the form of vapor is applied directly over the *open* or *naked fire*, or indirectly, that is, by *steam* and the *water* or *sand bath*.

Heating by the Naked Fire.

Distillation over the open or naked fire consists in effecting the combustion directly underneath the still. This method of heating is most usually employed in operations on a small scale.

The management of heat with the open fire requires much skill on the part of the distiller, especially when semi-liquid substances are to be distilled—as the marc of grapes, cherries, &c. The degree of heat is quite difficult to fix and to be equably kept up, for, when a small addition of fuel is made to the fire, the heat may pass all at once from the condition of being too low to that of being too high, and the distillate may contract an empyreumatic flavor.

An unequal distribution of heat with the open fire often presents the inconvenience of altering the product more or less. The liquid dries, and burns the upper

parts of the still, or, rather, some of the solid matters submitted to distillation attach themselves to the sides, and, by opposing an obstacle to the passage of the heat, favor its accumulation at such points; the product, under such circumstances, will inevitably contract a burnt flavor.

Heating by Steam.

The inconveniences which have just been pointed out in the use of the naked fire disappear entirely where steam heat is applied for purposes of distillation. There is, too, great advantage in its use.

These advantages may be summed up as follows:—

1. Economy of fuel—since it permits all the operations of the distiller to be conducted by the use of a single furnace, when otherwise each one would require a separate fire.

2. Economy of labor, and consequently greater facility of personal supervision.

3. Perfect regularity in the temperature necessary for the work.

4. And as a consequence of this regularity of temperature a superiority in the quality of the product.

It is admitted that most liquid bodies may be transformed into vapor. This change is called in general *evaporations;* it is *silent* when the vapors are formed at the surface of the liquid without any movement therein. When the vapors escape tumultuously the phenomenon is called *ebullition* or *boiling.* The latter only concerns us.

Ebullition, is the tumultuous evolution of steam which is formed in the body of a liquid and escapes in bubbles at the surface.

When any liquid contained in a vessel is submitted to the action of heat, a certain time elapses before the ebullition begins; this time is necessary for the vapor to acquire, by increase of temperature, a sufficient elastic force to overcome the pressure of the atmosphere; the boiling point depends on this pressure; in proportion

as it is diminished the temperature necessary to cause ebullition is also diminished. In a vacuum ebullition is independent of the temperature. It begins instantly, and continues until the vacuum is filled, and then ceases.

The heating of liquids, or materials to be distilled, is effected by several methods. When, without inconvenience, they can be mixed with water, the steam is admitted directly or by *injection*. This is used for semi-fluid substances, or for the distillation of substances in the large Belgian or column stills. But generally with the simple or continuous stills, arranged by Derosne, Egrot, etc., rectifying stills, etc., the liquids are heated by *conduction from the steam*, that is to say, by causing a current of steam to circulate in it through a tube usually arranged in a coil. Or the steam may be admitted into a jacket (or envelope) surrounding the still, or into a double bottom; these last are used only by the spirit distiller.

We would recommend that the greatest caution should be observed, in admitting steam into any apparatus, to open the steam-cocks slowly, so as to avoid too great and sudden condensation in the pipes, which will occasion detonations and shocks which injure the joints of the pipe and cause leaks.

Those who are desirous of acquainting themselves with the calculations for the force of steam boilers for heating purposes, are referred to the catalogue of H. C. Baird for several valuable books on the subject of the steam-engine and its applications.

NOTE.—The use of the water and sand-baths being confined to another branch of the art, the consideration of them is deferred until we treat of distilled waters, etc.

CHAPTER V.

SOME CONSIDERATIONS UPON DISTILLATION AS APPLIED TO ALCOHOL.

A DISTILLING apparatus to be profitable should be so constructed as to be able to heat the liquid rapidly, and to evaporate and condense it with facility. We may now add, as a sequel to these principles, that it is necessary, 1st, to heat at the same time, and equally, all parts of the mass subjected to distillation; 2d, to remove any obstacles that may interfere with the ascent of the alcoholic vapors; 3d, to effect the condensation promptly in order to prevent a portion of these vapors from escaping in the gaseous state.

In order to obtain the first of these conditions it is necessary, in the first place, that the mass of liquid should be of little depth, and should present a large surface; that the heating, whether by the naked fire or by steam, should be conducted with intelligence and care, so as to maintain the stream of the distillate of regular size, and in order to avoid shocks.

The ascent of the alcoholic vapors always goes on satisfactorily when the first condition is fulfilled, but care must be taken in a *continuous* distillation not to turn the wine or fermented must into the apparatus before it has acquired a temperature of at least 80° Cent., for if the wine be cold or only tepid the operation will be interrupted.

The alcoholic vapors are always promptly condensed when the liquid contained in the cooler is sufficiently cold, that is to say, does not exceed a temperature of 18°; nevertheless the vapors should not come over in such great abundance that the condensed liquid will be warm.

Accidents of Distillation.

The following accidents may occur during the course of an operation :—

1. Leaks in the apparatus.
2. Insufficient exhaustion of the spent liquòr.
3. Imperfect condensation of the alcoholic vapors.
4. Fires.

Leaks in the Apparatus.—When the joints of the apparatus are not well made, or when the screw taps or bolts are not tight enough, there will be an escape of alcoholic vapor, which will occasion more or less loss, and may be the cause of fire. The accident may be easily prevented by being careful to apply between the joints a cement of white and red lead mixed with oil, and to examine the taps and bolts occasionally to see if they are tight enough.

Some loss of liquid or vapor may occur when there are cracks in the soldered joints necessary to the adjustment of the coils, wine-heater, and cooler; but in this case the liquid which flows into the proof bottle will be sensibly lowered in strength, and will at once indicate what is going on in the apparatus.

Insufficient Exhaustion of the Spent Liquor.—The liquid which has been subjected to distillation, that is to say, the residuum which results from this operation, is called *spent liquor.*

The insufficient exhaustion of the *spent liquor* can only occur when we distil too quickly the quantity of liquid which should be distilled in a given time, or when the apparatus used is defective. This last danger of loss will disappear by using the apparatus we have described.

Testing the Spent Liquor.—We ascertain whether the liquid submitted to distillation contains any more alcohol, as follows :—

We open the air-cock, placed on the top of the still, containing the liquid to be examined; a small quantity of vapor escapes, to which a lighted match is applied; if it takes fire it is evident that the spent liquor still contains a certain quantity of alcohol.

If, however, there should be any doubt about this test, it may be better to use the following:—

Connect the air-cock, by means of an India-rubber tube, with a small cooler similar to that of a test-still; open the cock half way, and the vapor will be condensed into liquid within the coil. This product when collected is tested in two ways: first, by throwing a small quantity on the top of the still, and applying a lighted match; if it burns, the exhaustion is not complete; second, by plunging into the liquid an alcoholmeter; if it marks two or three degrees, it is proof that the liquid contains more alcohol, and distillation must be continued until the liquid marks zero, then we may be certain that it is despoiled of its alcohol.

Imperfect Condensation of the Alcoholic Vapors.—This accident may happen when the liquid of the cooler is not sufficiently cold, or rather when, in consequence of a *shock*, there is disengaged so great a quantity of alcoholic vapor that a part will escape in a gaseous state, while the other part flows into the proof bottle in the form of a hot liquid.

The first cause readily disappears by taking care that the cooling liquid, as has already been said, does not exceed 18° in temperature, or by replacing the wine in the cooler by water; in this case the wine passes directly into the wine heating condenser. The second takes place only when the fire or steam is pushed too actively. By regulating the heat this accident is prevented.

Fires.—A distillery should be so arranged as to avoid all chances of conflagration. With this view the alcoholic products of the distillation ought to be received in reservoirs of iron, or tanks of oak lined with tinned copper, hermetically closed, and if possible in a separate place. The spirits that are rectified, or are ready for consumption, ought also to be placed in a special store.

Leaks of the apparatus, and the imperfect condensation of the alcoholic vapors, may frequently become the cause of fire, these vapors being exceedingly inflammable. The smallest flame is sufficient to set them on

fire, and when a room or building is filled with this vapor the explosion which follows is truly terrific.

The same accident may occur from the escape of the ethereal vapors, which are produced at the beginning of a distillation, or during rectification.

All danger of fire is avoided by being careful not to enter, with a candle, a place where distilling is carried on, or where spirits are stored, without using a lantern —the use of Davy's safety lamp is to be preferred. The lamps necessary for lighting the establishment should be inclosed by glass or mica, and finally, if it is possible, to distil only during the day, the risk will disappear almost entirely.

CHAPTER VI.

DISTILLATION OF ALCOHOL.

Now that we have explained the theory of the general principles of the distillation of alcohol, it becomes our province to set forth the rules for their practical application; for the connection between theory and practice is indispensable, and it is vain to separate them. The operator who is not guided by theory is like a blind man who walks without seeing his way. Practice is action; theory explains the why and wherefore it is done; it indicates the means to be employed to insure success, as well as those to which we must have recourse to surmount obstacles which might prevent its attainment.

We set up no claim, in order to arrive at the end we have in view, to fix limits to the progress of distillation. We believe, on the contrary, that there is much yet to be learned. We have made, since we have practised the art, some interesting and valuable observations, founded on science and work, which have proven to us that the actual state of our knowledge in regard to distillation

is far from being perfect. Moreover, every day brings new discoveries to enlarge the circle of our knowledge! Be this as it may, we shall explain in simple terms all the operations which are practised in our day for the production of the different kinds of ardent spirits which are found in the market. We shall add to these the results of our own experience, which, we are persuaded, ought to be taken under consideration.

Spirits of Wine (Alcohol from Wine).

The distillation of wines is one of the most fruitful sources of prosperity to France, and its development in the United States may yet lay the foundation for a branch of trade which will render great aid in restoring to its originally prosperous condition a portion of our beloved country, so lately prostrated by intestinal strife.

The manufacture of all kinds of liquids, capable of yielding alcohol, being of necessity the province of the distiller, we shall devote some space to the mode of preparing wine from grapes. The limits of this work do not permit us to enter into all the details of this interesting subject, and for more extensive information our readers are referred to special treatises, of which there are many.

Wine.

Among the fruits which contain the elements necessary for the vinous fermentation the grape occupies the first rank. It has within itself the sugar, the water, and the ferment in the most suitable proportions. These substances are, however, variable according to the climate and changes of seasons; nevertheless it is these, added to a *bouquet* or peculiar aroma, which constitute that valuable liquor, known as wine, and its infinite varieties.

France, situated almost in the centre of Europe, is, by its topographical position, and by the nature of its soil, the richest country in vines, and that in which they best succeed. In the plains and on the mountains, here in the sand, there among the rocks, and everywhere

vineyards, old or new, yield their choicest products. That which especially distinguishes the French wines is their bouquet, their delicate flavor, and that valuable lightness which renders them inoffensive and superior to all foreign wines.

In many parts of the world wines are made, of incontestable merit, but which, nevertheless, generally fatigue the organ of taste, and which impress on the nervous system a state of excitability often dangerous; sometimes it is from their extreme tartness; sometimes a flat and unsavory flavor, which is caused by an excess of sugar and the ropiness of the liquid; and sometimes from the harshness resulting from an excess of alcohol. In France there are innumerable varieties which answer to all the fancies of the most capricious taste, of a good color, a generally irreproachable limpidity, strength, fineness, mellowness, bouquet, delicate and light aroma, and a gracious perfume, which flatters, charms, and soothes the nerves, but rarely injures, except when abuse is mingled with their enjoyment.

Vintage.—The name applied to the season of the grape harvest, and the various labors necessary to the manufacture of wine.

The vintage calls for the preparation of many details. We should be careful to provide the number of puncheons or hogsheads for which we may judge that we shall have need, to have them gauged and in good order, to make the necessary repairs to the press and vats, to have ready wooden shovels, iron forks, tubs and buckets of wood, funnels, panniers, and baskets.

We ought to await the perfect maturity of the grapes before gathering, otherwise the wine will be sour, and keep badly. The true period of this maturity is when the berry begins to soften and falls at the slightest touch, when the stem becomes brown, and the expressed juice is sweet and sticky. The ripeness of the white grape is recognized by the transparency of the berry, its sweet taste, and by its brown spots.

Grapes should be gathered as soon as possible after the dew has disappeared, using for the purpose the scis-

sors or shears. The knife jars the bunches, and causes the best berries to fall off. It is proper to handle them with care, so as not to bruise them, and to transport them to the place where the wine is to be made without jolting them.

Crushing.—In order that it may yield a vinous liquor it is necessary that the grape should be crushed, to the end that its proximate elements may be brought into more intimate contact; for there would not be any alcohol in the berry if left to itself; unless it be torn it will wither, dry up, and be decomposed without undergoing a regular and complete vinous fermentation.

There are many ways of crushing the grape—each country has its own. The following appears to us to be the best :—

We use a square box, open at the top, the bottom pierced with holes; it is placed on two pieces of wood, which rest on the edges of the vat; within this box a vintager places himself, and tramples the fruit with his great sabots; the expressed juice flows into the vat; then, by a sliding side-gate, he causes the marc to fall into the vat; this is thrown into another vessel, if the must is to be fermented alone. The crushing goes on as described until the vat is full.

The crushing in the fermenting vat, directly, as is done in some countries, is highly objectionable; a great part of the berries not being mashed, it follows that the sugar and ferment contained in them, although floating in the liquid in full course of fermentation, will remain untouched because still inclosed in their cells, and when the grapes are pressed these berries yield a juice which will ferment in the hogshead.

It is a question among wine makers whether it is proper to stem the grapes, but all doubt ceases when it is fairly examined. The stems containing, in fact, neither aroma nor saccharine matter, contribute nothing to the strengh or the bouquet of the wine. Then, if the grape is not in a state of complete maturity, either from want of heat, or because the vintage has been hastened by frosts, or from any cause whatsoever, the stems can

only contribute, by their acidity, to increase that produced by the grape in this condition.

But, on the other hand, there are feeble and almost insipid wines, such, for the most part, as come from humid climates, in which the slightly acid taste of the stems relieves the natural flatness of this drink. It was so in Orleans, that, after having commenced to stem the grapes, they were forced to abandon it, because it was observed that the grapes which were stripped from the stems furnished a wine which very easily became ropy.

It has been also observed that the stems of the grape increase and regulate the fermentation of the must; that they give to the cap a degree of permeability necessary to the escape of the carbonic acid, in such a manner that the stems may be considered as an advantageous ferment in all cases in which it may be feared that the fermentation will be slow or incomplete. They contain, too, an astringent principle which contributes to the preservation of wines containing a small quantity of alcohol.

At all events stemming is but little practised, except in two-fifths of our wine-growing departments, or by some large proprietors, who take the greatest pains to obtain wines of the best quality.

Vatting.—The grapes, after being crushed, are to be turned into the vat; a vacant space of 20 or 25 centimeters is left, because of the increase of volume which occurs in the mass in consequence of the heat developed during fermentation and the escape of carbonic acid gas. The vat is then covered, and fermentation suffered to go on.

The vats for the vintage are of oak, and are round; they are brought together and strengthened by wooden hoops, but iron hoops are better, as they are more solid. The contents vary from 20 to 25 hectolitres; they should be larger at the bottom than at the top; they rest on trustles, and are furnished with a stopcock for racking. Vats of masonry are preferable for the proprietors of large vineyards, especially when the wine is intended for distillation. They may be heated before being filled.

The plastered lining of these vats has a sensible action on the wine only the first year.

Chemical Composition of Must.—The recently expressed juice of the grape is called must. It is a sweet liquor, agreeable to the taste, which contains no alcohol, but only those elements which are proper for its development and the formation of wine.

In order to explain the phenomena which take place within the vat during the fermentation, it is necessary to make known the composition of the must or juice of the grape. We find in it cellulose, water, glucose or grape sugar, pectic acid, malic acid, tannin, vegetable albumen, an azotized substance called albumen or glaiadine, and which appears to produce the ferment, an essential oil, a violet-colored substance situated under the skin of the grape, fatty matter, acid tartrates of potash, lime, and alumina, sulphate of lime, and chloride of sodium. Of all the substances which are found dissolved or suspended in the must, the most important is the glucose or grape sugar; the other substances are but accessories.

Fermentation.—The grapes having been disposed as described above, the fermentation will in a few days have established itself, the mass becomes heated, bubbles of carbonic acid are disengaged so abundantly as to present the appearance of ebullition; they raise the solid debris of the fruit, and a thick scum consisting especially of altered ferment, in such a manner as to form by degrees on the surface of the liquor a hemispherical crust which is called the *cap*. But very soon the effervescence is calmed down, and the cap subsides. The vat is now stirred so as to mix all the materials and revive the fermentation. When the liquor ceases to effervesce, when it has acquired a vinous taste, and has become clear, it is drawn off into hogsheads. It now bears the name of *wine*.

The fermentation is feeble when the temperature is cold at the season of the vintage; heat being, as we know, one of the primary conditions of the vinous fermentation, it is necessary in order that it may go on

properly that the cellar in which the wine is made should have a constant temperature of 15° Cent., and of course that the fruits should be at the same degree. This result is attained by heating the cellars with stoves and allowing the fruit to remain uncrushed until it has acquired the temperature of the place. We can, too, produce the proper temperature by drawing off a portion of the must, and heating it nearly to the boiling point and returning it to the vat.

When the progress of the fermentation is not diminished, it is unnecessary to stir or plunge the cap into the wine. In any event, instead of sending naked men into the vat (which is both nasty and dangerous, asphyxia often resulting from the carbonic acid gas generated during the process), it is better to depress the cap by a wooden plunger with a long handle.

A majority of wine growers prefer the open vats; this was the method of our fathers. Although the loss which takes place in open vats has been greatly over-estimated (since Gay-Lussac has shown that it does not exceed the half of one per cent. of alcohol), it is better to cover them. Indeed, in the open vats, if the atmosphere is dry and warm, the cap becomes dry and the air penetrates it; and if the fermentation is prolonged, acetic acid will be formed, and when the cap is mixed with the mass by stirring, it will communicate to the wine a disposition to assume the acid fermentation. If the air is cold and moist, the upper surface of the cap will absorb water which will dilute the grapes, and cause the development of the acid or putrid fermentation and incipient mouldiness.

Fermentation in closed vats conbines the following advantages. The interior temperature is maintained, and the must before beginning to ferment ripens. The green fruit thus attains a degree of maturity similar to that which would have occurred on the vine if the season had been favorable. The air has no influence, the evolution of carbonic acid is retarded, and the wine may be left for a longer time in contact with the marc with-

out any other inconvenience than the solution of the elements of the stem.

Improvement of Must.—When the season has been cold or rainy, or the grape has been grown on moist lands, the must contains too much water of vegetation, and too little sugar. In this case, in order that the fermentation may not be irregular, slow, and often incomplete, and that the product which results may not be deficient in alcohol, it is proper to restore the proportion of the elements by diminishing the water by artificial evaporation.

This operation not only restores the normal proportions of the elements of the must, but facilitates the clarification of the wine if it is not pushed too far. It must be remarked, however, that must which remains too long over the fire loses its fermenting properties. This phenomenon is to be attributed to the coagulation of a part of the albuminous, glutinous, and extractive molecules contained in the must.

The most natural means and those most in accordance with the principles of wine-making, in order to counteract the excess of water in the juice of grapes or other fruit, are to add some saccharine substance to the must; at the same time that we supply this defect in the work of nature, correcting the imperfect composition of the must, we supply to that liquid the quantity of sugar which would have been developed if the season had been more propitious: we do more; we produce at will the must of the south or of the north.

"Generally," says Chaptal, "when the grape ripens, the sugar and vegeto-animal principle (*ferment*) exist in proper proportions to undergo a perfect and regular fermentation, but when the season is moist or cold, the sugar is deficient, the mucilage is in excess, and the product of the fermentation is wanting in alcohol. In this case the small quantity of alcohol developed is not sufficient to preserve the wine from spontaneous decomposition, and on the return of warm weather a second fermentation is set up which decomposes the liquor and converts it into vinegar.

"This unprofitable result may be obviated by correcting artificially the imperfect composition of the must. It is only necessary to add the amount of sugar that is wanting and which nature has failed to produce.

"In order to determine the quantity of sugar to be added to must derived from unripe grapes, the following indication will suffice:—

"In the South of France the grape ordinarily ripens perfectly, and in this case it is only necessary to manage the fermentation properly; the wine will keep without alteration, but in the north, even in a favorable season, this fruit never ripens completely. I have constantly observed that, in the south, wine which has been well fermented marks on the areometer some fractions of a degree below the specific gravity of water, while in the North of France, the new wines rarely allow the instrument to descend to the same degree.

"Another important observation which may serve as a guide to the quantity of sugar which it is proper to employ each year, is to determine the degree of concentration of the must, which varies with every gathering. The areometer has often shown a difference of from two to four degrees of concentration in must resulting from the same vintage, as the maturity of the grape has been more or less advanced; the must from very ripe grapes weighs the most.

"Thus, when we have once determined the specific gravity of must derived from grapes which have attained the greatest maturity, it is sufficient to bring it to this degree by the addition of sugar in seasons when the ripening is less perfect.

"In 1817 the grapes of Touraine had not ripened; the must of my vintage, which marked 11° in a good season, was only at 9°; I brought it up to 11° by adding sugar. I covered the vat with boards and woollen cloths, and allowed it to ferment. The wine was found to be very clear when drawn from the vat; it was almost as strong as that from the south, while that which had been vatted without the addition of sugar was flat and thick, as the thick red wines of the wine-

growers constantly are. The latter sold for fifty francs the barrel. I refused eighty-four francs for mine, preferring to keep it for my table. The wine, as it was drawn from the vat, was as clear as that made from the same vineyard, and which had been four years in barrels, and it was much more generous and agreeable to the taste. *Twenty barrels of wine prepared in this manner required fifty kilogrammes of sugar.*

"As the grapes are crushed and the vat filled, some of the must is put in a boiler over the fire and heated sufficiently to dissolve the sugar. When dissolved, the solution is poured into the vat and the mass carefully stirred. This operation is to be repeated until all the sugar has been disposed of. When the operation is finished the vat is covered and the fermentation suffered to proceed."

The habit of sweetening must to improve wines is at present general in Burgundy, Champagne, Orleans, and many other wine-growing countries, only glucose is preferred as offering more analogy to the sugar of the grape than cane sugar. Yet it would be, in our opinion, more advisable to use white refined cane or beet sugar for table wines even of a low price, and to use glucose for common wines; by this means we should avoid increasing in the wines the formation of amylic alcohol, which the fermentation of the glucose of starch always produces in a variable quantity, and independently of the alcohol resulting from the decomposition of the saccharine matter.

Drawing off. (*Racking.*)—The quality of the wine depends in a great measure on this operation; but, all-important as it is, the wine-growers, even in our day, depend only on equivocal signs. They have imagined a number of signs and circumstances by the assistance of which they pretend to ascertain the propitious moment; but it is easy to understand that this period cannot be fixed, because the phenomena vary in energy and duration according to climate and season, or, rather, according to the temperature at the time of the vintage, and also according to the quality of the must. We may, there-

fore, affirm that all methods, the object of which is to fix the period of racking in a general or precise manner, are necessarily fallacious. The only one that will furnish a sure guide consists in observing, during the fermentation, the progress of the decomposition of the saccharine principle, that is to say, the complete vinification of the liquor. The areometer may, under certain circumstances, aid in determining the stage of fermentation in the must.

Expressing.—The whole of the wine is not obtained by the operation of drawing off; there remains a very considerable quantity with the marc which forms the cap, which sinks down as the wine is drawn off, until it forms a single mass with the parts deposited at the bottom of the vat. The marc is expressed by means of a *wine-press.* This has various forms, which are more or less perfect.

This expressed wine is frequently mixed with that drawn off without pressure; but this is wrong; it should be kept separate, because it is harsher, less ripe, and more tart than the latter.

Chemical Composition of Wine.—We shall omit the details of racking, sizing, sulphuring, and storing wines, as well as some other operations in regard to this subject, as not being within the limits of a treatise like the present. We cannot speak of the distillation of wine without pausing a moment, as was done for must, to consider its chemical composition, from which it differs but little.

Wine contains a large proportion of water, a little undecomposed glucose, traces of soluble azotized matter or ferment, alcohol in variable proportions (from 7½ to 24 per cent.), pectine and mucilage, some tannin, free malic and tartaric acids; a coloring matter, yellow in white wine, and red in the dark wines; acetic and *œnanthic* acids; an aromatic principle or *bouquet*, and *œnanthic ether*, an essential oil of vinous odor; and, finally, all the vegetable and mineral salts contained in the must.

The wines of Bordeaux contain, in addition, a sapid principle called *œnanthine*, and the champagnes an appreciable quantity of carbonic acid gas.

The numerous varieties of wines have very nearly the same composition, although the constituent elements are not always in the same relative proportions. These substances pre-exist in the marc of the grape beside some which are generated during the act of fermentation.

The alcohol, acetic and œnanthic acids, the bouquet, œnanthic ether, and œnanthine, are the products of the fermentation of the must. The alcohol is derived evidently from the sugar. The *acetic acid* is formed at the expense of the alcohol, and is almost always the result of a too active or too prolonged fermentation.

The *œnanthic acid* analogous to the fat acids results from the oxidation of the fatty substances contained in the must; its action as an acid is but little appreciable to the taste, but it is observed in proportion as it is transformed into œnanthic ether by its reaction on the alcohol; this œnanthic ether is a sort of essential oil, which appears to be the principle which communicates, not the *bouquet* peculiar to each locality, but that characteristic vinous odor more or less common to all wines. As to the *bouquet* of wine so much prized by *gourmets*, it is a substance which, by reason of the minute proportion in each kind of wine, has hitherto escaped all the researches of the chemist.

Wines are generous and strong in proportion to the amount of alcohol they contain. It is this principle to which they owe their intoxicating properties. The tannin gives them roughness and the acetic and malic acids, and cream of tartar, their tartness. As the tartar is deposited by degrees in the casks and bottles, it may be well understood how wines improve by age. They lose, too, by keeping, a large proportion of their coloring matter, and acquire a tint which has received the name of *onion peel*.

Choice of Wines for Distillation.

In the choice of wines the distiller is principally decided, first, by the alcoholic richness, and then by the quality of the product he can obtain.

The alcoholic richness of wines is easy to determine by means of the test-still of Gay-Lussac or Salleron (*see determination of the strength of alcoholic liquids*). It is sufficient to distil off one-third of the wine to be examined, and then add to the distillate two volumes of water, and plunge an alcoholmeter into the mixture. This instrument, with the aid of a thermometer, will at once indicate the degree of spirituosity, or, in other words, the alcoholic strength of the wine tested.

The proportion of alcohol in the different kinds of wines varies very much; it depends on the nature of the climate and soil on which the wines are grown. The strength of wines may be deduced, as we have seen, from the proportion of alcohol which they contain, but their value, in reference to the quality of the product they will yield, is not so easily determined. This value depends on numerous circumstances which cannot be ascertained by the taste alone. In general wines that are rich in alcohol have neither the mellowness nor the perfume, which characterize the light wines; but, on the other hand, it is certain that they contain less malic acid. It is also to be remarked that generous wines yield the best *rectified spirits* (*trois six*). The distillation of alcohol from wines (*spirits, trois six*), having for its object to procure a perfectly pure product, that is to say, free from taste, neither the bouquet, fineness, taste, nor the age of the wines is indispensable to the success of the operation. In brandies, however, as we shall see hereafter, all these qualities are to be sought for. Besides, in the choice of wines, we should be guided by the experience acquired in regard to each particular locality. They should be examined simultaneously by the taste and the small test-still referred to above; these will not only make known the quantity of alcohol, but will also throw some light on the quality of the product.

Distillation.—This operation is generally conducted in the continuous apparatus, the use and management of which we have described (apparatus of Derosne & Egrot). By means of this method of distillation we obtain at once the desired degree (86 or 88 degrees), we exhaust the liquid completely, and economize a large quantity of fuel. It is, however, possible to distill wines with the simple apparatus; but, in this case, it is necessary to redistil the product several times to procure the degree of concentration required by the trade; this will necessarily lead to a great loss of time and considerable expenditure of fuel, without yielding a product equal in quality to that obtained by the continuous apparatus.

Trois Six or Spirits of Wine (Rectified Spirits).

In this trade these names are applied to the alcohol of wine, marking 85 degrees Centigrade, or 33 degrees of Cartier. The denomination *trois six* is very old, and constitutes with the following, viz., $\frac{2}{3}$, $\frac{3}{4}$, $\frac{3}{5}$, $\frac{4}{7}$, $\frac{5}{9}$, $\frac{6}{11}$, $\frac{3}{7}$, $\frac{3}{8}$, and $\frac{3}{9}$, the ancient fractional denominations which are used in the South of France, at the present day, to designate spirits of different degrees of proof, and which correspond to 23, 24, 29, 30, 31, 32, 35, 37, and 41 degrees of Cartier's areometer, the temperature being at ten degrees of the thermometer of Reaumur. These numbers are not arbitrary; they indicate the weight, and not the volume, as some theorists have contended, of the quantity of water which it is necessary to add to any spirituous liquor to bring it to proof (*Preuve de Hollande*), or 19 degrees Cartier (50 degrees Centigrade).

Thus the three-fifths is spirits at 29½ degrees, which mixed in the proportion of three parts of spirits with two parts of water, will give five parts in weight of brandy at 19 degrees.

The trois-six is alcohol at 33 degrees, of which, if three parts are mixed with an equal weight of water, will produce six parts of brandy of the same degree, or 19 degrees Cartier.

The trois-six of wine is at present used exclusively in

the manufacture of *liqueurs*, and for improving common brandies; the great advance in price for many years, has caused manufacturers to have recourse to the spirits of beets and grain for these purposes.

Fine or well-flavored trois-six should be perfectly pure, without aroma, and besides should be absolutely limpid. Badly flavored trois-six is detected by its empyreumatic taste, resulting from careless distillation, or the *flavor of the still*, caused by too hurried a rectification, or the taste of the marc, of the beet, or produced by an admixture of the spirit manufactured from these substances.

In examining it, trois-six should never be tasted, unless it is diluted with at least half its weight of water; this is necessary to develop the aroma that may exist in the spirit; besides it would be very difficult to taste it pure, as the power of taste would be blunted by the strength of the spirits. Yet there are some dealers who have no difficulty in tasting trois-six by dipping in the point of the little finger and carrying it at once to the mouth. We may also, in order to recognize the odor of badly flavored trois-six, pour a few drops into the palm of the hand, and then after striking the hands together, let them approach the nose.

The engraving exhibits the general arrangement of a first class brandy distillery.

Alcohol from Molasses.

Molasses is the uncrystallizable syrup which is produced during the manufacture of cane and beet sugar. It is the residuum of the manufacture and refining.

Molasses is a brown, viscous, and very dense liquid, marking generally from 41 to 45 degrees on Baumé's areometer, and rarely above. Its color varies from a clear yellow to almost black, according to its origin.

Variety and Selection of Molasses.—The selection of molasses is a matter of very great importance to the distiller, as much in respect to the quantity as the quality of the alcohol it will yield. The best is that

which is of a beautiful amber tint, without any burnt taste, and in which are still found particles of crystallizable sugar.

Frequently, we confound the molasses of the refineries with that from the colonies, from which *taffia* and *rum* are made. The taste is of excellent quality, and sometimes contains as much as 60 per cent. of sugar.

The molasses from the refinery is made from (1) cane sugar, or (2) beet sugar.

The first is to be preferred as containing much more sugar, but it is scarce and always high priced in France.

The molasses from the refineries of beet sugar, in its turn, should be preferred to that from the factories. It furnishes a larger quantity and better quality of spirit than the last. The molasses from the beet sugar factories lacks that fresh, agreeable, and honey-like taste which characterizes the product of the cane factories and refineries. It retains a bitter and acrid taste derived from the root. It is strongly alkaline, because of the salts of potash which it contains in considerable quantity, and has an unpleasant odor. Because of its bad taste, this molasses cannot be employed for any other purpose than distillation.

Fermentation.—The following is the process of fermenting it, whatever be the kind of molasses selected. Dissolve the molasses in four or five times its weight of water, or in seven or eight times its volume, at pleasure,* of which a certain portion should be heated to 30° C., in order that the mixture may be complete; the cold water is then to be added so as to reduce the temperature of the mass to 20° in summer, and 25° in winter. The proportions indicated will yield a must, the density of which will vary from seven to eight degrees of Baumé's areometer.

As the liquid is often strongly alkaline, especially when operating with molasses from the beet sugar fac-

* One hundred kilogrammes of molasses at 42 degrees, represent 71.43 litres by measure; 100 litres of molasses of the same degree will weigh 140 kilogrammes.

tories, it becomes necessary to remedy this inconvenience which would otherwise prove an obstacle to the regular development of the fermentation, and consequently, the production of alcohol. The alkalies are neutralized by the addition of a slight excess of sulphuric acid. This is determined by the use of litmus, which reddens instantaneously by contact with an acid.

The exact quantity of acid to be used cannot be fixed, because the quantity of alkaline salts varies with the quality of the molasses. It may be stated as between three and four kilogrammes for each one hundred kilogrammes of molasses. The acid should be diluted in seven or eight volumes of cold water to prevent altering the saccharine principle in the molasses.

When the mixture is prepared, it is drawn into one or more vats according to the quantity, and the fermentation is established by adding 250 grammes of good fresh yeast, previously dissolved in a little tepid water, to each 100 litres of must at 7° or 8° Baumé. After introducing the yeast, the liquid is to be well rummaged for some minutes, the vat carefully covered and left for the fermentation to proceed. In a very short time under the influence of the yeast and heat the fermentation will begin to be apparent; the surface of the liquid will be covered by a light white scum which begins at the sides of the vat and gradually extends over the whole surface. This scum consists almost entirely of yeast; it is caused to disappear entirely by throwing on the surface of the liquid a little oil or grease, mixed with a small quantity of boiling water. In the absence of grease a little soft soap dissolved as above will produce the same effect.

When the scum has disappeared we perceive lively undulations of the surface of the liquid, at the same time that it exhales the very characteristic odor of carbonic acid gas, a manifest sign of the conversion of the saccharine principle into alcohol. To this tumultuous movement of the liquid succeeds another phase. As the undulations become less active, and in proportion as the fermentation diminishes, the evolution of carbonic acid

becomes less abundant, it is remarked that the sweet taste of the liquid also diminishes and insensibly disappears; then the vat acquires a very decided odor of alcohol—a sign which indicates the termination of the fermentation.

When the operation has been conducted under favorable circumstances such as have been indicated above, the vinous fermentation terminates usually at the end of thirty-six or forty-eight hours, and if it is not completed within fifty-five or sixty hours or more, the result will be a very bad one.

We know that the operation has progressed properly when the liquid only marks 0° or 1° on the areometer of Baumé.

When the alcoholic fermentation is terminated, the acids contained in the fermented liquid are neutralized by a slight excess of lime, which should be previously mixed with a sufficient quantity of water. The object of this addition is not only to neutralize the acids which exist in the wine, or are produced during the fermentation, but also to afford a means of arresting or at least of retarding, and in a great degree diminishing the progress of the acetic fermentation which, as we know, always takes place at the expense of the alcohol. After saturation the vats are closely covered and allowed to stand twelve or fourteen hours. During this period of repose the vinous liquid becomes clear, and the lime falls to the bottom of the vats, combined with the acids which it has neutralized, when we may proceed to the distillation by the continuous apparatus.

Admitting that we have operated upon good molasses, and that we have directed and watched the fermentation and distillation with the special knowledge which these operations require, we shall obtain ordinarily an average of 28 or 30 litres of *pure alcohol* from 100 kilogrammes of molasses at 42° (37 or 41 per cent.).

The alcoholic result will be materially increased if we use for a new fermentation the clear waste liquor which is derived from the previous distillation, by using it in-

stead of water to dilute the molasses. This method, practised at present in distilleries of molasses from beet sugar presents also the peculiar advantage of affording a more highly concentrated saline liquid from which to extract the potash it contains. There results from it a notable economy of labor, and especially of fuel for concentrating the waste liquor.

Since the waste liquor resulting from the direct distillation of the wine of beet molasses usually marks from 3° to 4° of the areometer of Baumé; and when used for a new fermentation we obtain after distillation waste liquor marking from 7° to 8°, we would call attention to the fact that in charging the vats we ought not to estimate at its full value the degree of the waste liquor used for diluting the molasses. In other words, if the charge of molasses for fermentation should be at 8°, and the waste liquor used had marked 4°, we should charge the vats at 12°, since there are 4° resulting from the waste liquor which count for nothing.

Some chemists advise the fermentation of molasses at 12° or 14°. This would in effect yield a more concentrated waste liquor, but experience has proven that by charging the vats at so high a degree there will be too much sugar lost in the waste liquor. For many years we have seen that the use of malt and rye-flour in the fermentation of molasses will produce an excellent effect. Five hundred grammes of each are to be employed for each hectolitre of the liquid to be fermented. It is certain that these substances perceptibly increase the fermentation, and produce a greater quantity of alcohol.

The spirit of molasses has neither the taste nor the odor of spirits of wine; it is sweeter, and when the distillation and rectification have been properly conducted, it may be considered as a type of alcohol in its purity, for it has neither taste nor any peculiar aroma. In this state it is called *fine spirits*, and may be employed in the manufacture of liqueurs, for improving common brandies, and especially for refining the *troix six* (rectified spirit) of Montpellier. The spirits of molasses

occur usually in the market at from 90 to 94 centesimal degrees.

NOTE.—In those districts of France where the beet is largely cultivated for the manufacture of sugar, and the molasses is converted into alcohol, the waste liquor is made a source of no inconsiderable profit by concentrating it and incinerating the residuum, from which is obtained, for the use of the soap boiler, a caustic potash of superior quality. In addition to the alcohol, 100 kilogrammes of good beet molasses will yield 10 or 12 per cent. of commercial, or from 7 to 8 per cent. of refined potash.*

Alcohol from Beets.

The manufacture of alcohol from beets, after having been for many years the object of a special industry, has now a tendency to become entirely agricultural; in fact, for many years only three hundred farmers had set up distilleries for beets, and this year (1867) at least double the number will be set in operation if alcohol still continues to rise in price. The advantages which this manufacture presents to the farmers are considerable. Producing the raw material themselves, they get it at a price to which the trade cannot aspire; they extract the alcohol by maceration at minimum cost. This work furnishes a residuum, which costs them almost nothing, and which, when fed to cattle, will fatten them visibly. On the other hand, the manure resulting from this food will, in its turn, improve the quality of the land already improved by the cultivation of the beet.

Finally, the distillation of the beet being conducted at a season when field work is interrupted, will afford occupation for the laborers.

From these considerations it follows that the industrial distillation of the beet should give way to the agricultural, and that, after awhile, will do so entirely.

Chemical Analysis of the Beet.—The following is the average of many analyses made at different times by intelligent and skilful chemists:—

* See *Dussauce: The Manufacture of Soap.* 8vo. Philadelphia: H. C. Baird.

Water	85	parts.
Sugar	10	"
Ligneous fibre	2.5	"
Albumen and other substances	2.5	"
	100	

The other substances not named are: malic and pectic acids, an azotized substance, red, yellow, and brown coloring matter, fatty matter, an aromatic principle, an acrid essential oil, chlorophylle, oxalate and phosphate of ammonia; the silicate, sulphate, nitrate, and oxalate of potash, the chlorides of potassium and sodium, sulphur, silica, the oxides of iron and manganese.

When the distiller does not cultivate the beets he wishes to distil, that is to say, when he is obliged to buy them, it is best to make a preliminary examination of them in order to be assured of their saccharine richness, for this varies with the species of beet, the method of cultivation, and the nature of the soil in which they are grown. Atmospheric influences also have their effect.

The most certain test, that which will give the best result, is, without doubt, to ferment the juice and distil the wine resulting from the fermentation; the proportion of sugar which previously existed in the roots is deduced from the quantity of alcohol obtained.

A very simple method of testing beets consists in cutting from the middle of a number of them some thin slices, which, after being carefully weighed in a small balance, are dried either in a hot room, or on a moderately-heated stove.

As soon as the drying is complete, which may be known when the slices have become so hard and brittle that they break in the attempt to bend them, they are again carefully weighed; the difference in weight represents the quantity of water originally contained in the fresh beets. It is indispensable, in order to have the drying perfect, that the slices should be subjected to many successive weighings until they lose no more weight.

In order to determine approximately the quantity of sugar which the dried slices contain, we make the following calculation: Beets of a good variety, cultivated in a proper soil, and in a favorable season, would have 16 to 18 parts of dry matter for 100 parts of the fresh root; we should subtract 7 or 8 parts for the foreign substances, and there will remain 9 or 11 parts representing the proportion of pure sugar, or, in other words, 9 or 11 kilogrammes of sugar from 100 kilogrammes of fresh beets, of which it will be possible, when operating on a large scale, to obtain from 4 to 7 kilogrammes of refined sugar, or from 7 to 11 litres of spirit, at 50° Centigrade (proof), representing 3½ to 5 litres of pure alcohol, because the beets only yield about four-fifths of the alcohol, and only one-half or two-thirds of the sugar they contain.

Another method of testing as simple as the preceding, but much more prompt, consists in ascertaining the density of the juice of the beets examined, and is as follows:—

Some beets are rasped in an earthen pan, and the pulp pressed in a cloth, the juice filtered through paper; then plunge an areometer into the liquid, and the degree of density will indicate the saccharine value of the beets with sufficient accuracy. This operation should be conducted quickly, and at a temperature below 15° Cent., in order to prevent the juice becoming thick and beginning to ferment.

The yield of alcohol from beets is dependent on the quantity of sugar they contain; it increases with the density of the juice, but not in proportion to it, on account of the saline matters and vegetable albumen which the roots contain in very variable proportions. Yet it is ascertained, according to a number of experiments, that beets, when they are matured, will generally yield 8 or 9 per cent. of sugar when their filtered (but not defecated) juice marks 6° on the areometer of Baumé, 9 or 10 per cent. when it marks 6½°, and 10 or 11 per cent. when the density is 7°.

Different Processes for Distilling Beets.

The principal methods at present used for obtaining alcohol from beets are:—

1. By rasping and pressure.
2. By maceration.
3. By direct distillation of the beet, that is to say, without rasping and without maceration.

As to the method of boiling the beets, and then extracting the saccharine juice by pressure, or subjecting the pulp to fermentation, then to distillation, it is at present almost entirely abandoned.

Each of the processes that we have just indicated receives in its turn different applications which we shall examine in succession.

The manufacture of alcohol, whatever be the process adopted, requires many operations, viz., washing the roots, rasping or slicing them, extracting the sugar, fermentation and distillation.

Distillation of Beet Spirit by Rasping and Pressure.

This process is employed in the large industrial establishments, and especially in the sugar factories, which have been converted during the last four years into distilleries. It requires a large stock and numerous hands, and, as a consequence, furnishes alcohol which costs a pretty high price. Therefore this process offers but little chance of success in the future, although the alcohol produced by it is undoubtedly superior to that obtained by any other process.

The beets are washed, rasped, and pressed by suitable instruments. By this treatment are obtained from 80 to 85 parts of juice for 100 of beets; but the quantity may be made up to 100 by allowing a small stream of water to fall on the rasp; this will, at the same time, facilitate the rasping.

Frequently, during the pressing, when the temperature is above 12° Cent., or when the beets are somewhat damaged, the sacks which contain the pulp will become

thick or slimy, and still retain after this operation a certain quantity of liquid, nowithstanding the force applied. This inconvenience may be avoided by occasionally plunging the sacks into water containing two or three one-thousandths of tannin in solution, or five per cent. of sulphuric acid at 60 degrees.

The extraction of the juice of beets, by rasping and pressure, demands the most constant attention to cleanliness; for the sacks, hurdles, reservoirs, and other implements may produce changes which will react with very great rapidity upon must otherwise of good quality, and cause serious damage. We should, therefore, every day wash the reservoirs, presses, tables, &c., with lime-water. The sacks are to be placed in a large rectangular box, hermetically closed, and into which is introduced a current of steam. When they have been submitted to this operation they are rinsed in lime-water, or acidulated water (five litres of sulphuric acid, at 60 degrees, to 100 litres of water).

The juice resulting from the rasp and press is then brought together in a boiler, and heated by steam to a temperature of 26 or 28 degrees, then it is conveyed by a pump or elevator to the fermenting vats.

Although the beet contains a natural leaven, the fermentation should, nevertheless, at the start be developed by means of beer yeast, in the proportion of 50 or 60 grammes to the hectolitre of juice. This yeast should previously be carefully mixed with a small quantity of water or must, and the temperature of the apartment should be at 18 or 20 degrees Cent.

It is indispensable, in order to regulate and hasten the fermentation, to add to the liquid about two or two and a half kilogrammes of concentrated sulphuric acid for 1000 litres, according to the richness of the must, and more particularly according to the quantity of foreign substances which it may contain. This dose, however, ought never to exceed three kilogrammes; for then the acid would produce a contrary effect, that is to say, would hinder the development of the fermentation. The office of the sulphuric acid, in this case, is to satu-

rate the alkaline salts, and to give the liquid an acid reaction which will favor the conversion of the starchy elements into sugar, and the transformation of the sugar into glucose, which, as we know, requires no ferment to produce the alcoholic fermentation. This transformation always precedes the conversion of saccharine matter into alcohol and carbonic acid. Sulphuric acid also prevents the development of the viscous fermentation, otherwise so frequent in beet juice obtained by rasping.

According to M. Dubrunfaut, the office of the acids employed in the fermentation of the beet is to destroy the cells of that root, and to facilitate the extraction of the sugar; then to produce, by heat or cold, a sort of defecation which precipitates in a solid state the various azotized substances, especially the glairy ferment. Be this as it may, it is certain that by the employment of the acid, if the beet juice is placed in the condition of a favorable temperature, it will undergo a perfect and very regular alcoholic fermentation without the intervention of beer leaven, and that all the sugar contained in the juice will be converted into alcohol, under the influence of the natural ferment of the root, transformed into an exclusively alcoholic ferment by the reactions of acids.

The acid may be advantageously added at different stages of the operation—on the rasp* by dissolving it in the water which flows on the drum of this machine during the rasping of the beets, in the trough of the rasp with the pulp after it has passed the machine, or when moistening the sacks already pressed, when they are submitted to the press a second time. In this addition the

* The acidulation of the pulp on the rasp, that is to say, at the moment of its production, preserves it radically from all change, either by oxidation or otherwise. The pulp remains white, the juice is limpid or colorless, the sacks and other utensils are cleansed, and will thus be kept perfectly sweet even without washing. The cells of the pulp not torn are dissolved, and, if we follow up the work by moistening the pulp with pure water, and pressing a second time, as is done everywhere, we shall obtain a new juice rich in sugar, and at the same time remove from the pulp the small quantity of acid which it would have retained but for this method of treating it.

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dose of acid should be calculated upon the weight of the beets as juice, and even above, because the earth on the roots, which may have escaped the washer, will neutralize a portion of it.

It is known that the quantity of acid is sufficient when the pulp is colorless, and the slightly-colored juice is quite clear. A rapid fermentation, that is to say, one which is effected after a delay of less than eighteen hours, with a foam that is white or grayish, light, easy to reduce by the aid of any fatty liquid, is also an evidence of a proper quantity of acid. Blackish foam, or one that becomes so by exposure to the air, indicates the reverse.

It is easy to avoid irregularity in the dose by verifying the state of acidity of the juice, which ought to be, as was said above, from two to three kilogrammes of sulphuric acid, at 66 degrees, for 1000 litres of juice, according to its density, and the nature of the beets from which it is obtained. The dose of acid in the juice is ascertained with sufficient exactness by means of the alkaline test solution, graduated test glass, and litmus. As a general thing two kilogrammes of sulphuric acid will be sufficient for a juice marking 103 degrees on the densimeter, or five degrees on the areometer of Baumé.

Hydrochloric acid may be used with advantage to replace sulphuric acid for the acidulation of the juice or pulp of the beet.

This acid, which possesses a marked superiority as an agent for changing crystallizable into grape sugar, and for the conversion of amylaceous substances into sugar, enjoys also the same superiority as an agent for the destruction of the cells of vegetables. Besides, hydrochloric acid produces the development of the ferment and the alcoholic fermentation with a greater economy of time and money.

The proportion which the hydrochloric acid should bear to the dose of sulphuric acid is that of their chemical equivalents; that is to say, about two kilogrammes of hydrochloric acid (commercial) for one kilogramme of sulphuric acid at 60°.

The fermentation of a vat, while yet in a state of activity, may serve to produce a new fermentation in another vat without the addition of beer yeast; it is sufficient for this purpose to draw off one-half of the liquor into the second vat, and to fill the two vats with fresh acidulated juice; the fermentation is then developed and progresses without interruption, and may be the means of a new fermentation. The reaction is instantaneous, and takes place with great activity.

During the fermentation of beet juice there is produced quite a large quantity of globular ferment which forms the cap, and which has properties analogous to the yeast of beer, but is possessed of almost double its fermenting power. This ferment is collected in the same manner as that of beer, and may be applied to the same uses.

When the fermentation is terminated, which happens generally 18 to 24 hours after the juice is introduced into the vats, the wine is allowed to rest for some hours, and then it is distilled in the continuous still, and in the manner already indicated. It is known that the fermentation is at an end, and the wine ready for the still when it only marks 0° or 1° on the areometer of Baumé, instead of 5° or 6° as at the commencement.

There is formed during the fermentation of juice obtained by rasping and pressure a very great quantity of foam which may overflow the vats and spread on the floor of the sweat-house; this inconvenience is easily prevented by the use of a solution of soft-soap or grease, as has already been said.

The deposit of the vats ought never to be used as a leaven for a succeeding operation; it only contains a spent ferment which will do more harm than good. It may be understood from this how necessary it is to clean the vats with care after each operation, and according to the principles indicated above.

The alcoholic result is dependent on the saccharine richness of the beets, and the more or less advanced state of the season. It varies between three and five litres of pure alcohol for 100 kilogrammes of fresh beets.

Distillation of the Beet by Maceration.

Maceration is an operation by the aid of which is extracted by means of water and spent liquor, all the saccharine principle contained in the beet.

The object of extracting the juice by maceration is to suppress the rasp and press, which call for the expenditure of much mechanical force, and carry with them also too great an encumbrance of expense and *personnel.* Then, too, we obtain by this process five or six times as much residuum as by rasping, which is a great advantage to the farmer; nevertheless, it must be acknowledged that the alcohol produced by maceration preserves a little more of the taste peculiar to beet-spirit than that obtained from rasping and pressure.

There are many methods of applying this process, but we shall confine ourselves to those in general use.

Maceration by Water.—This should by all means be preferred as the *industrial process*, because it yields an alcohol having a less unpleasant odor than that obtained from maceration with spent liquor. Nevertheless, this process may be resorted to by the farmer, if he will restore to the residuum of the beets the salt or salts they have lost in the process.

Maceration by water is effective either hot or cold. The first method, although it furnishes a spirit of inferior flavor, presents the advantage of yielding a much greater quantity of sugar in a very much shorter time. The heat, by bursting the vegetable cells of the beet, facilitates the escape of the saccharine matter, the place of which is occupied by the water. It furnishes also a residuum suitable for feeding cattle. The second is longer, but furnishes a residuum which is better suited for feeding stock, while the alcohol is of better flavor; however it may be, the hot process is in general use, and we shall therefore commence by describing it.

Maceration by Heat.—The beets are to be washed in a special apparatus, and sliced by means of a root-cutter moved by horse or steam power, or if the distillery is of little importance, by the force of two men. In the last case a fly-wheel should be added to give a greater

impulse to the machine, and accelerate the cutting. In any event, it is indispensable that the root-cutter should make from 120 to 150 revolutions per minute, in order that the roots may be properly cut.

The knives of the cutter should be so arranged as to divide the beets into ribbons having a width of one centimeter to a thickness of one millimeter, and a variable length. These dimensions being rigorously observed, the maceration will be perfect.

It is best in order to save labor that the beets should fall directly from the washer into the hopper of the root-cutter.

The beets being cut as described, are placed in a macerator of wood or iron and *covered* with boiling water, acidulated in the proportion of two kilogrammes of sulphuric acid at 66° to 1000 kilogrammes of roots. This dose of acid should be increased to five kilogrammes if the beets are damaged.

After macerating for one hour the liquid is drawn off, and at once turned into a second vat charged with beets cut in ribbons, where it remains still another hour; it is then drawn off into a third macerator charged as before, and after standing the same length of time, it is drawn off into the fermenting vat. This juice should have acquired, during the three successive macerations to which it has been subjected, a density which differs but little from that obtained by the rasping process.

While the operation is going on in the second macerator, the first is charged anew with acidulated boiling water, which also remains one hour, and is then turned into the second macerator after its contents are drawn off into the third. Finally the beets are completely exhausted by a third charge of acidulated boiling water, which also remains one hour in the first macerator.

The pulp being exhausted, is removed and replaced by fresh slices; the first macerator is then charged with juice which has already passed through two macerators; it stands one hour on this fresh pulp, and is ready for fermenting.

The starting differs, as we see, from the regular course

of the operation, in this, that the first macerator receives three charges of acidulated water at the beginning, while it only receives one when the work is under way; the two other charges are made with juices which already have a certain density, as they are the result of exhausting two other macerators. In conclusion, each macerator, to be completely exhausted, must receive three successive charges of liquid at intervals of one hour.

When the temperature of the air is not too cold, the juice which results from the three macerations ought to be set to ferment without the necessity of being reheated; it is usually at from 22° to 24° of the centigrade thermometer.

The fermentation is started at first only by the assistance of beer yeast in the proportion of 125 to 150 grammes to the hectolitre. This yeast, carefully dissolved in advance in a sufficient quantity of water or juice, is poured into the vat before introducing the liquid, and in proportion as the latter is turned in, it is strongly stirred for some minutes in order to distribute the ferment properly. When the vat is full, that is, when the must rises to within 20 or 25 centimeters of the top, it is carefully covered, and the whole left to ferment in a local temperature of from 18° to 20°.

Since, as was said above, the beet contains a natural ferment, a vat which is fermenting will serve for developing a new fermentation in another vat without the use of any more beer yeast. For this purpose one-third or one-half of the must in the vat, after fermentation has commenced, is turned into a new vat and the two vats are filled during the course of the day with fresh juice. The fermentation will then proceed without interruption, developing itself and continuing its course to give rise to new fermentations.

Generally the fermentation of juice obtained by hot maceration is completed in the space of twenty-four or thirty hours; it sometimes happens that it is finished within eighteen hours.

It is essential to observe the precautions we have pointed out in regard to preventing the accidents that

may occur during the course of the fermentation, either from frothing or from the formation of acids, as well as those prescribed in regard to the cleansing of all the vessels and utensils.

The fermentation having terminated, as is known when the must has acquired an agreeable vinous odor, and when all internal movement has ceased in the vat, the liquid ought to mark 0° or 1° on the areometer of Baumé. In this condition it may be distilled at once, but it is better to let it cool for twenty-four hours in order that it may attain the lowest possible temperature as it is used for cooling the coil and condensing the alcoholic vapors.

When the fermented juice is sufficiently cool the distillation is at once commenced in one of the continuous stills described above. The distillate usually marks from 45° to 55°: it must be rectified to deprive it of the disagreeable odor it exhales at this feeble degree, and to obtain it in the concentrated form required in the market (90° or 94°).

The quantity of alcohol obtained from the beet is, as we have said, influenced by the amount of sugar it contains, as well as the season in which the work is carried on. In general 1000 kilogrammes of beets of good quality will produce, by the process just described, an average of 35 litres of pure alcohol, or 37.78 litres of spirit at 94°. This method of maceration, if it is thought proper, may be conducted in every particular, and without change with spent liquor—only substituting this liquid for boiling water.

New Method of Maceration by Heat.—We devised, some ten years ago, a system of maceration which is very simple and convenient: exhausting the beet completely, and which permits—1st, the heating of the liquid in the macerators by steam; 2d, the almost instantaneous emptying of the pulp contained in the macerators. This new arrangement has been introduced into a number of farm distilleries in France and Italy.

We shall now proceed to describe the apparatus and

the manner of using it. Pl. VI., Figs. 5 and 6, represent the front and end elevation of the macerators.

1, 2, 3, cylindrical macerators of iron plate of suitable thickness, each having two perforated diaphragms within—one fixed at fifteen centimeters from the bottom by supports and nuts; it serves to support the pulp, while it prevents it from being drawn off with the juice; it also facilitates the dripping of the juice. The other diaphragm has two handles, and is used to press down the pulp and prevent it from rising and running over; it is supported by three nuts (near the top of the macerator) which fit in three grooves in the edges of the diaphragm in such manner that, by giving it one-twentieth of a revolution, it prevents the pulp from rising.

a. Six bearings or boxes, of which each lower half is fixed by means of four screws to six posts of oak; the upper half is fastened down by two screws. In these boxes rest the trunnions which serve as points of support for the macerators, rendering it possible to turn them over in either direction. The pivot on the left is solid, that on the right consists of a pipe working in a stuffing box, the outer part attached to the steam-cock *b*, and the inner attached to the macerator.

b. Cocks by means of which steam is introduced into the macerator from the main steam-pipe c^1, and the branch pipes *c*. For this purpose a plunging-pipe e^1 is placed within the macerator, just above the bottom; this pipe, being pierced with holes along its whole length, facilitates the admission of steam, and its distribution throughout the entire mass. This pipe is indicated by the dotted lines.

d. Posts of oak.

f. Pipe having a diameter of fifty millimeters, and communicating with the elevator. On this pipe are three perpendicular tubes, of the same diameter, curved at the top in such a manner as to pour the liquid into the macerators. Towards the middle of these tubes are placed cocks *g.* to give passage to weak juice, water, or spent liquor. By means of these three cocks liquid may

be turned into any one of the macerators at the will of the operator.

h. Main discharge-pipe, fifty millimeters in diameter, conducting weak juice to the elevator, to be transferred to the macerators. To this pipe are attached three other curved pipes, each having a large funnel *i*. Each of these funnels has within a grating which prevents the pulp, which may be drawn off with the liquid, from obstructing the pipes, and is placed directly under the discharge-cocks.

k. Main pipe, thirty-five millimeters in diameter, for conveying the strong juice to the fermenting vats. On it are three funnels *l*.

m. Displacement-pipes, one end attached at *n* by coupling-plate and three bolts under the bottom of the macerators, the other end curved into the funnels *l*.

o. Pipe in the form of a semi-ellipse, having at its middle point a perpendicular pipe *q*, by which water is conveyed to the macerators. There is a cock at the extremity of each of these pipes.

p. Another pipe, curved and arranged in the same manner with cocks q^1, for conducting weak juice to effect the displacement of the concentrated juice.

The pipes *o* and *p* are in communication with reservoirs or vats, situated above the place in which the maceration is carried on.

o^1 and p^1. Connections with main pipes for water and weak juice.

The maceration by means of the vessels just described is started as follows:—

First, fill macerator No. 1 with washed beets, cut in slices of the size and thickness indicated (p. 117) in the preceding article. Then wet the mass with sulphuric acid, at 66 degrees, diluted in twenty times its weight of cold water, in the proportion of one and a half or two kilogrammes of acid to 1000 kilogrammes of roots. The dose of acid may even be increased to two and a half kilogrammes, according to the season and the condition of the beets. When this is done, place the diaphragm on the beets, which should be packed carefully and with-

out crowding; then open the cock *q* of the pipe *o* to admit cold water on the beets until they are covered; then turn on steam from the pipe *c* by cock *b*, opening it gradually and carefully, so as to prevent explosions caused by the steam coming in contact with the cold water, and heat the macerator until the hand cannot be borne on the upper part (60 or 65 degrees Cent.). At this stage close the steam-cock *b*, and permit the mass to macerate during forty-five minutes. When this time has elapsed, open the cock *j* to let the juice be conveyed to the elevator through the funnel *i* and the pipe *h*.

When the liquid in macerator No. 1 has been entirely drawn off, close the cock *j*, and open *q* of the pipe *o*, in order to fill the vessel again with water; heat to the same degree as in the first charge, and also allow it to macerate during forty-five minutes.

While the second maceration is going on in vessel No. 1, macerator No. 2, which has been previously filled with sliced beets, should be charged, by means of the elevator, with the juice from the first operation, which, on leaving the elevator, passes by the pipe *f* and the cock *g*; then heat to the same degree, by opening the steam-cock *b*, and leave it to macerate for forty-five minutes.

When this operation is finished, draw off the resulting liquid into macerator No. 3, which has been filled with acidulated beets in slices, and allow it to stand for a few minutes; send, by means of the elevator, the product of the second maceration of vessel No. 1 into the reservoir of weak juice, and open the cock q^1 of the pipe *p*, in order that the strong juice may be displaced. The weak juice pouring into the top of the macerator naturally presses on the liquid contained in it, and forces it to flow out by the pipe *m* and the funnel *l*, to pass through the pipe *k* into the fermenting vats.

The displacement of the strong juice should be accomplished in thirty or thirty-five minutes. We know that it is complete when the liquid which flows into the vats has the same density as the feeble juice, which was used to effect the displacement.

Generally we obtain one and a quarter or one and a half litres of strong juice for each kilogramme of beets, or from 1200 to 1500 litres for each 1000 kilogrammes of roots treated.

The macerators Nos. 1 and 2 should then receive each another charge of water, which must be heated and suffered to stand for the time indicated above, so that after this maceration No. 1 is completely exhausted, having received three charges of water. No. 2, on the contrary, must receive another charge to be entirely exhausted.

As soon as the third maceration of vessel No. 1 is completed the exhausted pulp is to be emptied. For this purpose the macerator is to be tilted into a horizontal position by tackle or a crank; then, with an iron fork, having two or three curved teeth, the pulp is to be drawn out into a hand-barrow, to be carried from the building. The exhausted pulp being removed, the vessel is again filled with fresh slices of beet, which are sprinkled with acidulated water in the proportions and manner indicated.

The displacement of vessel No. 3 being terminated, the juice which it contains is heated in its turn, as has been said, and, after a sufficient maceration, is transferred to vessel No. 1, in which the slices have been renewed; this juice is then displaced and conveyed to the fermenting vats by the same means employed for vessel No. 3, *i. e.*, by weak juice from the cock q^1.

Thus it is seen that by this method the beets are completely exhausted by three washings or successive macerations and displacement. In a regular operation it is always the juice from the second maceration which is poured over the fresh acidulated slices, and which is displaced by the third juice or that from the last washing, to be sent to the fermenting vats. The last charge is made with pure water or spent liquor, according to the process adopted by the distiller.

In this method special attention is to be given to the two distinct operations of maceration and displacement. The former is conducted at the will of the workman;

the latter should be made as gently as possible. To attain this last result, it is necessary that all other operations should be conducted with promptness, which is easy enough, if use is made of the elevator, which adds greatly to the value of this method, by reason of the rapidity with which the transfers of liquid are made, that giving more time for the displacement to be completed.

The strong juice obtained by the process just described, has a proper degree of heat, and is therefore ready for immediate fermentation. This operation and the distillation present no peculiarities of management that have not been described for juice obtained by other processes.

The advantages resulting from this system are:—

1. The employment of steam for heating, which is infinitely to be preferred for distilling and rectifying, to the open fire.

2. The distribution of the steam in each of the macerators, which affords time for any method of maceration that may be preferred, and gives a degree of heat as high as may be necessary.

3. The possibility of effecting displacement of the strong juice in a given space of time at the pleasure of the operator.

4. The filtration of the liquid which is effected during the displacement, and which admits of sending to the fermenting vats a much clearer juice than that resulting from other methods of maceration; the juice ferments readily, without producing any great amount of foam, and forms scarcely any deposit in the distilling apparatus, and yields low wines which by rectification will furnish alcohol at 94° of good quality.

5. The ease and celerity with which the macerators may be emptied and filled, being suspended on pivots that may be caused to swing or turn over easily. This last advantage is very important; it dispenses with the use of the awkward fork tongs used by some, which is very heavy work, especially when the macerators are large, for then the workmen are compelled to descend into the vessel, where they will be surrounded by vapors that

are more or less injurious to the health, and are certainly a cause of intense discomfort to those who escape other injury. By the employment of swinging macerators, these inconveniences disappear. It is sufficient to tilt the vessels to an inclination of 45° for the workmen to empty and cleanse them in a few minutes.

6. Finally, the regularity with which all the operations succeed each other, as well as the facility of execution.

As to the pulp resulting from this operation, it is most excellent for cattle, as we may readily understand. The slices, when placed in the macerators, will receive weak juice, water, or spent liquor. These liquids, in consequence of being heated with the beets, form regularly throughout the mass, a precipitate of various salts some of which adheres to each bit of the root; then comes the displacement of the liquid, which, by reason of the slowness with which it is effected, also deposits on the surface of the beets the vegetable albumen, coagulated by the addition of sulphuric acid. All the nutritious principles of the beet, except the sugar, are then preserved after the maceration by this process.

Maceration; the Cold Process.—The beets, after being washed, are divided into very thin slices by the root cutter, and are placed in a wooden macerating vat, then covered with water, acidulated with sulphuric acid at 66°, in the proportion of two or three kilogrammes of acid to 1000 kilogrammes of beets. After a maceration of two hours, the liquid is to be drawn off into a second vat containing fresh material, when it again stands for two hours; drawn off again, it is turned into a third vat containing a similar charge, where it stands the same length of time. This juice has then, during the space of six hours, passed successively through three macerators, and ought to have acquired a density almost equivalent to that of the juice obtained by the rasp and press. This juice is then heated to 22° or 24° C., and set to ferment as described for the hot process.

As in the hot process, each macerating vat receives three charges for the complete exhaustion of the slices,

weak juice replacing water during a part of the operation, thus giving a juice of proper density for fermentation.

The cold maceration is effected much more promptly when the beets are reduced to a pulp by the rasp, than when sliced, but the cost of the mechanical force required for the machinery is more expensive.

*Maceration of Beet Chips.**—Beets cut in slices by a root cutter, and dried on frames of wood or wire cloth in the open air, or in a drying room, are called *beet chips*. The object of thus drying the beets is to preserve and furnish material for the distiller at all seasons, so that he may continue his operations after the stock of fresh beets has been exhausted, or when the advance of the season does not permit him to employ them with profit; and further, it reduces the cost of transportation when it may be desired to send them to a distant market.

The maceration of beet chips is conducted as in the hot process, only it must be understood that it requires more water or spent liquor than the latter, because the chips absorb five or six times their weight of liquid in swelling to their original volume, and assume a condition almost equivalent to fresh slices.

The fermentation and distillation of juice obtained by this process are managed exactly in the same manner as that from other processes described—sulphuric acid being employed in the same proportion, allowing for the loss of weight by drying. We should advise the use of boiling water, as indicated above, especially when the farmer has an abundant supply, since it favors the division of the molecules of the root, and produces a better result than spent liquor.

It may be objected that beet chips will be less nutritious for cattle. We would reply that what is lost on

* No apology can be required for the use of this term, although it is ignored by the lexicographers. *Chips* are thin transverse slices of fruits dried. *Snits* are slices cut longitudinally and dried. The two words as given above are in constant use in the great valley of Virginia, where all kinds of fruits are dried for home consumption or for sale.—*Trans.*

one hand is gained on the other. The vat constructed of wood or masonry, with an opening near the bottom, which has an inclination towards the opening, is placed so as to receive the spent liquor as it runs from the still, after it has been filled with enough beet chips for a day's work. The next morning the spent liquor is drawn off to be poured over the manure pile, the value of which it greatly enhances.

If it is desired, to save the expense of fuel, and to avoid the construction of a special furnace for heating the water, it will be sufficient to construct a hot water tank of sheet iron, with an interior coil through which the spent liquor may pass before reaching the vats; this will heat the water, intended for the maceration, to a sufficient degree. This cistern may, also, if necessary, have beneath it a small furnace in the event of *boiling* water being required. The fuel consumed by this extra fire will be a trifle.

We have also remarked that there is an economy of time for the maceration, and that one-half of the sulphuric acid ordinarily used will be sufficient; because the boiling water lacking those organic principles which are obnoxious to the fermentation, attacks the cells of the beet more promptly and more energetically.

If, from any cause, this process cannot be employed, we should advise the adoption of the method of Leplay —the direct distillation of the beet in substance.

Maceration by Spent Liquor.—The value of this operation has been greatly over-estimated by some. It has, however, its advantages when the supply of water, as in some localities, is scant. It is sufficient to say, that spent liquor is used instead of water in the different stages of the operations, until it has acquired such a density as to become profitable for the manufacture of potash. The macerating vats should be one meter deep, and one meter in diameter, capable of containing about 400 kilogrammes of beets.

Direct Distillation of Beets.

Process of Leplay.—This operation depends—

1. Upon the direct fermentation of the beets cut in pieces or strips without extracting the juice, and without the addition of beer leaven, the slices being placed in circumstances to favor this reaction.

2. Upon the direct distillation of these strips by a current of steam passing through the mass without direct heat, and in such manner that the pieces preserve their form, and constitute a mass which may be fed directly to cattle.

The beets being properly washed, are cut by means of a root cutter in pieces, having the form of ribbons some centimeters long, two centimeters wide, and two or three milimeters thick; these pieces, when placed one above another, leave interstices for the passage of the steam which is to act on them during the course of the distillation.

When this operation is finished, the beets are put into sacks and placed in a vat having a double bottom, containing juice, which has already passed through a good alcoholic fermentation in such manner that they shall be completely submerged, which is effected by means of a perforated cover, which keeps the sacks down while it gives passage to the liquid and the carbonic acid disengaged during the fermentation. This begins instantaneously, and is usually completed at the end of ten or twelve hours. All the sugar is then transformed into alcohol. It is, however, still retained in the substance of the beet, having taken the place of the sugar.

The fermented slices have not altered in form; the original volume of juice has not apparently changed. The sulphuric acid is poured into this juice in the proportion of two or four kilogrammes at 66 degrees to 100 kilogrammes of beets in slices to aid in the conversion of crystallizable sugar into fermentable sugar, and for neutralizing the salts and other principles that may be injurious to the fermentation. The dose of acid depends on the nature of the beets, the soil where grown and the more or less thoroughness of the washing.

New slices of beets may be fermented in the same liquor, and the juice will answer for three or four operations without the addition of fresh juice or yeast. In fact this juice may be used indefinitely or until the ferment begins to lose some of its active properties, which is detected by the fermentation beginning to be prolonged; the fermented juice should then be distilled and replaced by fresh juice, fermented by the usual process. When at the beginning of the work there is not beet juice on hand, it is obtained by maceration with hot acidulated water and fermented with beer leaven.

The pieces of fermented beets are then withdrawn from the sacks and arranged for direct distillation in a peculiar but very simple still, which consists of a cylindrical column of wood or iron, somewhat similar to the bone black filters of the sugar factories. This column has a close cover with an opening connecting it with the coil which is cooled by cold water to condense the alcohol. There are a number of movable perforated diaphragms arranged within the column to support the pieces of beet and prevent them from packing. Between the lower one and the bottom of the cylinder, is a vacant space intended to receive the water of condensation which collects during the heating of the mass by the steam injected into this space by means of a cock placed below it. The steam, after penetrating this species of double bottom, escapes through the interstices left between the pieces of beet, heats them to the centre, disengaging the alcoholic vapors which rise into the layers of beets above, to operate upon them in the same manner as the vapor of water has on those below, and to become more and more spirituous as they rise. With a column three or four meters high, we can obtain alcohol of 70 or even 80 degrees. The contents of the several diaphragms are successively and completely exhausted of their alcohol, and yield a cooked pulp which, says M. Leplay, contains all the nutritious elements of the beet, even all the soluble salts, the sugar alone having disappeared. This pulp, which constitutes nearly fifty per cent. of the weight of the beets, keeps without difficulty,

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and is easily transported from the distillery to the neighboring farms. There is no spent liquor to throw out of the establishment.

Rectified Beet Spirit.

Like all spirits obtained from roots, that from the beet, it matters not what process has been used for obtaining it, contains an essential oil which communicates to it a peculiar harshness and indicating its origin, unless it is carefully rectified according to the principles we shall explain further on. But, on the other hand, when freed from this essential oil, beet spirit constitutes a liquid which is suitable for replacing spirits of wine entirely and without exception in all the uses to which the latter may be applied.

Grain Spirit.

The cereals have been long used in England, Belgium, Holland, Prussia, in the whole of Germany and America, for the manufacture of alcohol, known in the market as *grain spirit*. This trade, so useful to agriculture, and which has been forbidden by a royal decree in France for four years, has unfortunately never received that extension among us of which it is susceptible, for if the farmers were fully alive to the advantageous results which are to be derived from adding a distillery to their agricultural operations there would be no farm without one or more of stills. But blind and stupid routine is ever blocking the progress of the arts, even those of prime necessity, and in spite of the efforts of enlightened men, who sacrifice their time, and often part of their fortune, in propagating the results of scientific discovery, it requires ages to effect favorable changes. Mathieu de Bombasle is one of those who have sought with ardor to encourage the distillation of grains and potatoes, which he, with reason, considers one of the "Columns of Agriculture."

"There is not a farmer," says he, "who does not know that he should always cause a part of the crop to be consumed on his land by his cattle." In this man-

ner he retains the value of the food consumed in animal products, that is to say, in fat cattle, milk, butter, wool, &c., and he is assured, moreover, of a considerable quantity of manure for the improvement of the soil. It is not so advantageous to feed to his stock the grain and potatoes destined for them without first submitting to a distillation.

This food then yields a three-fold profit to the farmer. He derives from the sale of the spirits the price of the raw material, with a profit from the manufacture. He then has the increase in cattle which are fed with the residuum, and experience has proven that grain and potatoes which have furnished alcohol are almost as good food for stock as if given without having been submitted to the distillatory process; finally, he produces a mass of manure, which by increasing the following harvest of grains destined for sale, equally adds to the profits of the still, and leaves the land in a constant state of increasing improvement. These truths are so well known in countries where the operation of distilling is in the hands of the farmers, that they would believe that in giving up the business they would be renouncing their farms, and that even in years of scarcity, governments have refrained from prohibiting the distillation of grain, from fear of interfering with the sources of the following harvest—the more, because the grain which is distilled is not lost as food for man, since it is returned in the form of food of another kind, as meat, milk, butter, cheese, &c.

Choice of Grain.—The state of preservation in which grain is found in the market should attract the special attention of the distiller; that which is heated yields much less alcohol, as its fermentation is much less easily effected.

Its specific gravity is the most certain indication of the quality of grain; therefore that which will weigh the most for a given measure should have the preference, whatever be the purpose for which it may be intended.

The cereals which are most commonly used for purposes of distillation are barley, rye, and rice; but wheat,

oats, buckwheat, and Indian corn are also employed under some circumstances with advantage.

Barley being the grain which is used exclusively for the preparation of malt, because it germinates more readily, and develops a larger proportion of *diastase*, should hold the first place. It should be selected with large fine grains of bright color, well filled, healthy, and firm, without any foreign substance, free from chaff, and as fresh as possible.

Wheat, although of all the cereals that which has the most body, and furnishes the greatest proportion of the alcoholic principle, is but little used in distillation, because its market value is always above that of other grains, and the alcoholic product is not always in proportion to this. In selecting wheat for the still, that should be preferred which is farinaceous, compact, and heavy, and very dry, without being blasted; that in which the gluten is so abundant as to give a vitreous appearance to the fracture.

Oats should be heavy, bright, long, and well filled. It is but little employed on account of its high price.

Of all grains rice is the most proper for the use of the distiller. Its proportion of alcohol is considerable, and the product has a very good flavor. It should be a dull-white, slightly transparent, angular, elongated, without odor, and of a fresh farinaceous taste. The East Indies, Piedmont, and the United States furnish considerable quantities to commerce.

Rye produces also a very considerable quantity of alcohol, in proportion to its cost, but it is inferior in taste to that resulting from rice, wheat, or barley.

As for buckwheat and Indian corn, they are usually sold at a low price, and the distiller may, under favorable circumstances, and in some localities, employ them with advantage.

Chemical Composition of Grain.—Grain (of cereals) is composed of an envelope in the form of bran, and of a portion which when reduced to a powder under the mill takes the name of *farina* or flour. The flour of the different kinds of grain of which we have just spoken,

contains in itself various principles, the proportions of which vary not only for each of them, but for them all according to climate, variety, soil, or other accidental causes. These principles are starch (*amidon*), which constitutes the greater part, gluten in variable quantity, albumen, mucilage, a small portion of saccharine matter, and in some, phosphate of lime and other salts.

By a recent analysis the proportions of these proximate principles may be stated as follows :—

GRAINS.	Starch.	Gluten and other azotized substances.*	Dextrine, glucose, and similar substances.	Fatty matter.	Cellulose.	Silica, phosphate of lime and magnesia, and salts of potash-soda.
Wheat—average of five varieties	65.99	18.03	7.63	2.16	3.50	2.69
Rye	65.65	13.50	12.00	2.15	4.10	2 60
Barley	65.43	13 96	10.00	2 76	4.75	3.10
Oats	60.59	14 39	9.25	5.50	7.06	3.25
Indian corn	67.55	12.50	4 00	8.80	5.90	1.25
Rice	89.15	7.05	1.00	0.80	1.10	0.90

Among these proximate principles it is the starch which has the property of being convertible into sugar, and giving rise to the alcoholic fermentation and the production of spirit. The gluten and vegetable albumen have the property of transforming starch into saccharine matter. This change is, however, better effected by means of sulphuric or hydrochloric acid, germinated barley (malt), and diastase.

It should be remarked that those grains or seeds which are richest in gluten always contain the largest proportion of azotized substances, and, in general, more fatty matters, inorganic salts, and cellulose, but less starch. As this last principle is that which furnishes the saccharine matter, that is to say, alcohol, preference should

* The proportion of azotized substance has been deduced from the elementary analysis by multiplying the weight of the nitrogen obtained, by 6.5.

be given, for purposes of distillation, to those seeds which contain it in the greatest quantity.

Dextrine.—Starch which has been subjected to the action of hot water, and which is entirely dissolved, has acquired new properties, and then constitutes a new *isomeric* principle called *dextrine.*

The very feeble acids, aided by heat and diastase, have the property of converting starch into soluble dextrine, and they produce this curious effect in a very simple manner. Dextrine is obtained by turning into a boiler, containing 100 or 200 litres of water, at 25 or 30 degrees, from five to ten parts of sprouted barley (malt), raising the heat to 60 degrees; then add 50 kilogrammes of flour, stirring the mixture, which is kept at a temperature of 70 degrees, for twenty minutes. The liquid which was opaque and viscous becomes as fluid as water. The temperature is now rapidly raised to 100 degrees; it is then permitted to cool, the clear liquid drawn off, filtered, and evaporated to the consistency of thick syrup.

On cooling the dextrine becomes an opaque jelly, which, when dried, is hard and brittle like gum Arabic. Dextrine is transformed into glucose by the action of acids, or malt added in larger quantity.

Diastase.—This substance is a proximate principle which is developed during the germination of cereals, potatoes, &c., and which has the remarkable property of reacting on flour or starch so as to render all the starchy particles very soluble, forming first a gummy substance (dextrine), which is gradually transformed into glucose. It is a remarkable fact that diastase does not exist in grain before germination. This principle is produced in proportion as vegetation is established, and its office is to react on the starch so as to render it soluble, in order that it may contribute to the nutrition of the incipient plant.

In its pure state diastase is white, solid, uncrystallizable, insoluble in alcohol, soluble in water and dilute alcohol; its aqueous solution is neutral, and without any decided taste; left to itself, it is more or less rapidly

altered, according to the temperature, and becomes acid. This alteration, which is important in that it deprives diastase of its most remarkable property, takes place, although slowly, even in dried substances. For this reason it is not proper to prepare malt too long in advance of the time for using it. It is especially improper to keep it from one season to another.

The action of pure diastase on starch or flour made into a paste is most powerful. Fifty grammes of diastase are sufficient to convert 100 kilogrammes of amylaceous matter into dextrine and sugar; this transformation is effected more or less completely, according as the quantity of water employed and the degree of heat are more or less adapted to the operation.

Generally diastase is extracted from barley malt, which does not contain more than two or three one-thousandths; a greater proportion is obtained when the germination has been regularly conducted in all the grains, and when the *gemmule* or *plumule* has not been pushed too far in its development. This last is very important to be observed, for when the germination has been too much prolonged, it causes an absolute loss by diminishing the amount of saccharifiable principle. It is on this special reaction of diastase that is founded the art of manufacturing beer, syrup of dextrine, or dextrine.

The Alcoholic Product of Grain.—As with all substances subjected to distillation, the amount of alcohol produced from grains will always be dependent on their nature, their state of preservation, and the manner in which the various operations have been conducted.

As a general rule, when the operation has been managed under favorable circumstances, the average result should be as follows, viz.:—

100 kilogrammes	of	wheat	yield	32	litres of	pure alcohol.
"	"	rye	"	28	"	"
"	"	barley	"	25	"	"
"	"	oats	"	22	"	"
"	"	buckwheat	"	25	"	"
"	"	Indian corn	"	25	"	"
"	"	rice	"	36	"	"

The result given above is apparently very different from that obtained when the several grains are taken by measure, since they differ considerably in their specific gravities; wheat, for example, weighs much more for a given measure than barley or oats.

Preparatory Operations which are Necessary before Submitting Grain to the Alcoholic Fermentation.

There are six preliminary operations which are indispensable in order to fit grain for the process of fermentation, viz: 1st, Steeping; 2d, Germination (malting); 3d, Drying the Sprouted Grain; 4th, Grinding; 5th, Mashing; 6th, Infusion.

We shall proceed to each operation in turn, taking barley for an example.

Steeping.—The object of this operation is to introduce into the grain a sufficient quantity of water to determine the germination; it serves, too, to separate all the blasted or withered grains which float on the surface of the water, and also removes the various foreign substances which may be attached to the surface of the barley. For this purpose the grain is allowed to macerate in river or well water for thirty or forty hours, according to the temperature of the atmosphere, the quality or dryness of the grain, and the character of the water; in other words, the barley is placed in a vat of wood or a stone tank lined with hydraulic cement. A quantity of fresh and limpid water is poured on the grain, so that it may be covered to the depth of ten or twelve centimeters; the mass is left alone for the requisite period of time. This water, during the high heat of summer, ought to be changed every four or six hours, in order to avoid the establishment of fermentation during the steeping; in order to avoid disturbing the grain, an opening is made in the lower portion of the vat, through which the water may be drawn off at will, as fresh water is added above.

It is known that the grain is sufficiently steeped and softened when it is swollen, and yields readily when pressed between the fingers, when it may be completely

crushed without leaving a hard lump or when it is divided easily by the nail. When it is in this condition the water is drawn off, care being taken that none of the grain is drawn off with it. To prevent such an accident the vat is provided with a double bottom, or a layer of straw is placed over the orifice of the vent.

The operation of steeping requires the most careful attention, for if the grain is steeped for too long a time, it will lose a portion of its saccharine matter.

Germination.—Barley which has not been subjected to germination will not answer alone for making spirituous liquors, but when converted into malt it can effect the conversion of a large quantity of flour into saccharine matter. It is therefore important, to indicate precisely the most advantageous method for preparing this malt, which plays so important a part in the distillation of grain.

After drawing off the water which covered the grain as described above, it is allowed to drain for four or six hours, and is then conveyed to the *malt-house.* This apartment is situated usually on the ground floor, or, better still, in a cellar, in order that the temperature, which should be regulated at 12° C., may not be subject to variations. It is always paved with tile or stone.

In the malt-house the barley is arranged in *couches* or beds of 50 or 70 centimeters high until it becomes sensibly heated. This heat, which is favored in winter by covering the beds with sacking or blankets, is produced by a commencement of vital movement in the grain, and is generally manifest in from twelve to twenty-four hours after the couches have been prepared. At this stage the grain gradually absorbs oxygen from the air, and exhales carbonic acid at first slowly, but afterwards with more rapidity. The temperature of the mass sensibly rises, and at the end of a certain time it has attained a temperature exceeding that of the atmosphere by six or seven degrees; the barley which had become dry on the surface then acquires so much moisture as to wet the hand when thrust into it; it exhales an agreeable odor somewhat similar to that of apples;

when this moisture is observed the grain is said to sweat. It is not proper to permit the grain to become too warm, because it will sprout too rapidly, and the saccharine matter will be destroyed. It is proper, also, to turn the grain over every six or eight hours, placing that which was on the top at the bottom, and that in the middle on top of the pile, taking care always to keep the floor very clean, to prevent the formation of mould and putrid odors.

As soon as the germ appears, which happens when the barley sweats, and when a small white prominence is seen at the end of each grain, which is soon separated into three little roots, which increase in length very rapidly, the barley should be turned every three, four, or five hours, according to the temperature, by which this operation should be regulated. As the process proceeds the beds should be made thicker or thinner, so as to maintain a temperature of 15° or 16°. When the germ is long enough the grain ought to be turned twelve or fifteen times a day, according to the season. When the germination has been checked, and the little roots begin to dry, the thickness of the beds must be reduced so as not to exceed eight or ten centimeters; they must be stirred and changed frequently in order to prevent the rootlets from resuming their growth, to avoid moulding and to prevent the grain from sprouting, that is to say, giving issue to the seminal leaves at the extremity of the seed opposite the roots, for this would deprive the barley of a great part of the substance which yields alcohol.

It is difficult to indicate the exact period for the germination; it varies from eight to fifteen days, according to the season. We know generally that the process is terminated when the rootlets have attained a length equal to about two-thirds of that of the grain.

Germination causes the production of the diastase which is necessary to transform the starch into glucose; it has then for its object to convert a small quantity of the fecula of the grain into sugar, at the same time that it predisposes the rest to a more complete and prompt

saccharification by giving to the gluten the property of being more readily dissolved.

Drying the Malt.—We have shown how important it is to arrest the germination promptly, for without this precaution the saccharine matter which has been developed by this operation in the grain at the expense of the starch, which is, as we have said, saccharified by the action of the diastase, will be destroyed, and the grain will pass rapidly to a state of putrefaction after having run through the acid fermentation. These accidents, then, must be forestalled by drying the grain by a gentle and well-regulated temperature in order to arrest the germination.

The drying is effected in an apartment called a *kiln*. The grain is spread on the floor in beds of twenty or thirty centimeters thick, then subjected to a temperature which, at first, should not exceed thirty-five degrees; but should be gradually increased to fifty-five or sixty degrees at most, until the grain is almost entirely dried. This temperature is most favorable to producing a good quality of malt. If too great a heat is employed at the beginning while the grain is yet very moist from being filled with water, the starch will expand, become hydrated and form a stiff paste, and then acquire so much hardness and cohesion as to be very difficult of solution. When the grain is almost dry, the heat may be raised to 80 and even 100 degrees without risk, the diastase being alterable at this temperature only when water is present. Nevertheless if the grain is dried at a temperature sufficiently high to convert the sugar into caramel, the diastase will be destroyed, there will be a loss of sugar, and the malt will have a less agreeable flavor.

Barley sprouted and dried is called *malt*. When the heat has not been sufficient to change the color it is *pale malt;* when the heat has caused a decided color it is *brown malt*.

When the malt is well dried, it is drawn from the kiln and spread out to cool in a well-ventilated room and stored in piles. It may be preserved for a long time if protected from moisture. The freshest is however the best.

Various means are employed for *kiln-drying* malt; plates of sheet iron or tiles perforated with small holes are used, metallic cloth of iron or brass is also in use in some establishments, and is to be preferred to the sheet iron or tiles. We would especially recommend the process by heated air. The method of heating by gas jets, recently patented in Great Britain by Hademul of Leeds, is as a combination of the various systems an improvement. Certainly if the results obtained by him are fairly stated, there is great profit both in the improved quality of the product and economy of fuel.

The choice of fuel for kiln-drying malt according to the old method, is by no means a matter of indifference; if wood, for example, be used the grain will acquire the taste of the smoke which will be transmitted to the beer in the fermenting vats, and consequently to the spirit resulting therefrom. Coke either specially prepared or that from the gas-works is the best, the next is wood charcoal.

When the malt is sufficiently dried and while it is yet warm it is passed through a winnowing machine, which will completely separate all the radicles, which are very brittle. There is no real loss from the separation of the radicles, as they contain neither diastase, starch, nor sugar. They yield by infusion a reddish water of disagreeable taste, and if some time is allowed to elapse before the separation, the radicles will, under the influence of a little moisture, resume their elasticity, which will render them difficult to break off from the grains. They are only fit for manure.

Barley converted into malt, loses about an average of 20 per cent. of its original weight, but this 20 per cent. is to be diminished by 12, for the water evaporated during the drying, therefore the real loss is 8 per cent., which may be stated as follows, viz:—

Substances removed by the water during steeping .	1.5
Matters lost during the sprouting, &c. . . .	3 5
Radicles	3.0
	8.0

Malt is known to be of good quality when the grain is round and full of farina, the skin very thin, odor agreeable and taste saccharine, or better still, by the energy of its action on starch, 100 parts of which may be dissolved by 5 parts of good malt in 400 parts of water, if the mixture is placed in a water-bath maintained at a temperature between 65 and 80 degrees and continually stirred. In conclusion, pale dry malt is the heaviest and best for distillation.

Grinding.—It is necessary that malt should be ground to facilitate the action of the water on the farinaceous matter which, without this operation, would be prevented by the skin. Every grain should be crushed, but not reduced to flour; for those which escape the action of the mill, will be lost to the fermentation. It must not be supposed, however, that malt reduced to a flour cannot be fermented, it is only crushed to save labor, and because experience has shown that malt coarsely ground will yield all its fermentiscible principles.

Fine grinding is preferable for raw grain, that is to say, for unmalted grain; and in fact this cannot be too finely ground. Thus crude rye, wheat, buckwheat, rice, Indian corn, and barley ought to be ground in the same manner as if intended for making bread. In this condition the material will be more promptly penetrated by the water, and will thus facilitate the action of the diastase on the starch, to effect its conversion into sugar.

It is known that musty grain, whether unground or in flour, appreciably loses its fermentiscible properties. To avoid this inconvenience distillers should grind their grain as it is needed. It should also be observed that malt after being ground attracts more moisture from the air than when whole. That which has been on hand for some time, or has absorbed moisture, ought to be mashed with warmer water than freshly prepared malt.

Mashing.—The object of this operation is to wet and soften, with a certain quantity of warm water, the substances of the crushed malt as well as the flour of the various grains that may be mixed with it; it prepares these substances for receiving a larger quantity of water at a

higher temperature, and appears too to prevent the agglutination of the mass by the formation of lumps and balls which might prove an obstacle to the water penetrating all parts of the mass.

The malt and grain either crushed or ground into flour are shot into a vat; warm water in the proportion of a litre to the kilogramme is turned on in small quantities at a time, in such manner that the temperature shall not exceed 35 or 38 degrees. While the water is being poured in, a workman must stir the mass continually, beating it in every direction so as to prevent the formation of lumps and cause every portion of the flour to receive a thorough wetting; after which the vat is to be closely covered and permitted to rest for twenty or thirty minutes or more.

We should observe during this operation to pour in the water gradually and in small quantities at a time and not to raise the temperature higher than that indicated above, for a greater heat will coagulate the albumen of the grain, will *cook* the starch, and in a great measure prevent the action which the gluten and diastase ought to exercise on it.

Infusion.—The object of the infusion is to cause the diastase of the grain to react on the starch, which has been thoroughly divided by the mashing, in order to convert it into saccharine matter and to predispose it to a fermentation, which it would be impossible to undergo without it.

This very important operation is effected by pouring boiling water into the vat until we have obtained a temperature of 60 or 70 degrees Cent., while a workman stirs the mixture energetically for ten minutes at least. When the requisite degree of heat has been attained, the vat is covered closely and allowed to macerate for four hours. It is proper during this time that the temperature of the vat should not fall below 50 or 55 degrees, and it is even preferable that it should be maintained at 60 degrees.

We would remark that it is proper to employ a little more heat for the maceration of a small vat than a large one; and also that in winter the heat should be much

greater than in summer. In any event if the temperature should happen to fall to 40 or 45 degrees, it will be better to set the malt to ferment at once rather than prolong the maceration, because there must be a loss of a certain quantity of alcohol in consequence of the acidity which will infallibly be produced at this low degree.

The temperature of 60 degrees is the most proper for this maceration, as being that at which the saccharification is effected most rapidly. Not that it cannot be effected at a lower temperature, at 40 degrees for example, but it is then more tardy, and we are exposed to the risk of seeing the whole mass become acid if it is exposed for some hours to this temperature, and this would be an irreparable loss. If, on the other hand, we exceed the temperature of 60 degrees, there will be no inconvenience up to 68 or even 72 degrees; but at 75 degrees mischief begins to be manifest, and above 75 degrees the fermentation is exposed to serious injury; it will fail altogether if the temperature is raised to the neighborhood of 100 degrees. It appears that the gluten, which is, in this operation, the vehicle of saccharification, only possesses this property when it has not been exposed to too high a temperature. Heat contributes very much to its action and renders it much more intense; but the maximum of utility of this heat is from 60 to 72 degrees.

The proportion of water also plays a remarkable part during the maceration. The greater it is, the more prompt and complete will be the saccharification, all other circumstances being the same. Let us take an example: generally when we wish to treat 100 kilogrammes of flour we mash with one hectolitre of water and add two and a half hectolitres of water for the maceration. This then is completed in the space of four hours; but if the dose of water is doubled, that is, if we use three hectolitres for mashing and four for the maceration, the operation will be as perfect as the preceding in the space of two or two hours and a half. So much for the influence of water upon saccharification.

Now that we have set forth the principles of the operations to which the grain must be subjected before submitting it to the alcoholic fermentation, we shall proceed to occupy ourselves with this last.

Alcoholic Fermentation of Grain.

When the operations which we have described above are completed, that is, when the maceration is finished, the barley is submitted to the vinous fermentation; for this purpose, as it contains a sufficient quantity of saccharine matter, it suffices to mix it properly with cold water so that the temperature may be at from 20 to 26 degrees, according to the volume of the mass operated on. Liquid beer yeast is then added in the proportion of one litre of yeast to 100 kilogrammes of grain (or 250 grammes of dry yeast), the vat is then covered and the fermentation is soon established.

The mash ought to be cooled promptly in order to prevent acidification during the operation. Never make a mash unless it can be set to ferment immediately.

The chemical analysis of a must thus obtained gives for its results: 1st. A saccharine substance, which constitutes the most abundant portion of it; 2d. Starch, which it is easy to recognize by the blue color obtained with tincture of iodine; 3d. A combination of tannin and gluten; 4th. Mucilage, which is precipitated in flocks when the must is poured into alcohol. The proportion of gluten is inconsiderable, and that of the starch varies according to the more or less perfect character of the mashing.

As a general thing where the various operations have been well managed, the fermentation progresses with perfect regularity and lasts from two to three days; but it is only twenty-four hours after it is finished that we proceed to the distillation in a continued apparatus for pasty materials.

We have taken barley for our illustration in all the preparations and arrangements we have described, be-

cause malted barley is the very essence of the distillation of grain and potatoes, not that this grain has properties which are peculiar to it, but because it possesses them in a much higher degree than any other.

There are many methods of distilling grain. We shall examine those which are most in use in the farm and agricultural distilleries of Europe.

Method of Dombasle.—"Suppose," says he, in his valuable Treatise on the Manufacture of Spirits from Grain and Potatoes, "that it is desired to ferment 100 kilogrammes of flour (80 kilogrammes of rye and 20 kilogrammes of malted barley), the fermenting vat should contain six or seven hectolitres, not counting the space which ought to remain empty. The water must be heated to the boiling point and maintained at that degree for some minutes; a portion is then to be cooled down to 50 degrees for making the paste. For this purpose we use a vat which is much wider than deep, and which contains three or four hectolitres; this is the *mash tun.* The flour is turned in and the water at 50 degrees is gradually added with continual stirring in such manner that the flour may be thoroughly moistened throughout, without the formation of lumps. We should continue to add the same water until the temperature of the mass is reduced to 31 or 33 degrees; the vat must then be covered and allowed to stand for half an hour. We should then take some of the water which is still boiling, and pour it into the mash tun in small quantities at a time, stirring the mass continually so that no part of the flour may be exposed to too great an excess of heat until the mass has attained about 62 degrees. The vat must then be covered and allowed to rest for two hours. It may be permitted to rest even three or four hours if the mass is large, or if the temperature of the apartment in which the operation is conducted be sufficient to prevent the heat from diminishing too rapidly. At the end of this time the vat should be uncovered and the liquid stirred so as to cool it as rapidly as possible. A method which has been very successful in accomplishing this cooling, consists in filling a copper

or tin flask of a capacity of 25 or 30 litres and having a long neck, with cold water, which is plunged into the liquid and gently moved about therein. When the water becomes warm it is changed and the operation continued until the liquid has acquired the proper degree of temperature. This degree ought to be calculated so that when the mass is conveyed to the fermenting vat and enough cold water is added to fill the vat to the desired point, the liquid shall have the proper temperature for adding the yeast. As soon as the mass is sufficiently cooled it is transferred to the fermenting vat and the last of the cold water added; it should then have the proper temperature for adding the yeast, as has been explained before. This varies from 20 to 25 degrees according to the season, the size of the vats, the nature of the grain used, &c. By the assistance of the thermometer we shall soon ascertain the proper degree for each distillery and every circumstance that may require attention. If the yeast is added when too hot, the fermentation will take place promptly, will be very active, and the liquid will become acid on the second or third day. If, on the contrary, the yeast is added too cold, it will be easily discovered, because the fermentation will take place slowly and will have but little activity; then too, the acid fermentation will commence before the vinous fermentation has sufficiently advanced. As a general rule, when the yeast has been properly added and in sufficient quantity, the fermentation has already begun two hours after the addition of the yeast, and in twelve hours is very active, and so continues until the third day. Thus a vat which has been set to ferment on Monday, will present during the whole of Tuesday an active fermentation with an elevated foam and very strong odor; if a lighted candle is plunged into the empty part of the vat it will be very promptly extinguished. On being tasted, the liquid should still be sweetish without any acidity. On Wednesday, the foam will have very much diminished, and the liquid be no longer sweet but vinous, although not yet acid. On Thursday the foam will have completely fallen and settled

to the bottom of the vat; the liquid is almost clear and slightly acid. and there is generally found on the surface a whitish pellicle. This is the proper condition in which to subject it to the action of the still.

"I have advised that the mashing should be performed in a separate vessel; nevertheless it is the common usage of distillers to make the mash in the fermenting vat directly. I prefer the former method, because it is easier to cool the mass in a large vat of little depth than in the fermenting vat, which is much deeper than broad. Besides, in transferring the mass to the fermenting vat, which is cold, it will lose two or three degrees, which is so much time gained in the cooling, and it is very important that this should be accomplished as promptly as possible. By making the mash in the fermenting vat, it is necessary to add a very much greater quantity of cold water to reduce the mass to the degree of heat proper for adding the yeast, and we have in consequence a very weak wine.

"I have indicated 62° Cent. as the most favorable temperature for making the mash. It is in fact that which is best under the greatest variety of circumstances, and we shall never fail in a fermentation from having made the mash at this degree; nevertheless, there are circumstances in which we obtain a greater quantity of spirits by making the mash some degrees above or below 62°. These circumstances are so numerous that it is impossible to give precise rules for each. We should always be governed by experience, with the thermometer in hand that it may direct us. We may say, however, that, in general, the mash should be much warmer in winter than in summer; for small vats than large, and as much warmer as the proportion of malt is increased."

This process, by reason of its simplicity, like that spoken of by us before, may be practised in farm distilleries of the least importance; both require but little hand labor, a small number of vessels, and consequently not much capital.

Another French Method.—Suppose that we intend to operate on one hundred kilogrammes of grain:—

According to Dubrunfaut, the grain being mixed in the proportion of 80 parts of rye and 20 of malt, is reduced to coarse flour, then deposited with two or three kilogrammes of chaff,* in a fermenting vat of a capacity of 12 hectolitres. These materials are then moistened with three hectolitres of water at about 43°, and then made into a mash with four hectolitres of cold and boiling water, mixed in such proportions that when the mashing is completed, the mixture shall have a temperature of 62° or 68°. The vat is then covered and left to itself for three or four hours; after this time has elapsed, the vat is to be filled to within six or eight inches of the top with cold and hot water, mixed in such proportions that the whole mass shall have a temperature of about 25°. It is set to ferment with a litre of good liquid beer yeast.

"After a few hours, the fermentation commences, and runs through all of its stages in the space of about thirty hours. It is then in a proper state to go into the still.

"If the grain is of good quality and the operation properly conducted, the result ought to be from 45 to 50 litres of proof spirit (50° centesimal).

"Many distillers only obtain from 30 to 35 litres by this process. There are many circumstances which may concur in causing this result; the principal and most influential is the proportion of water employed; instead of using about 11 hectolitres of water to 100 kilogrammes, they only employ about six.

"In a continuous operation the spent liquor (or swill), which is drawn from the still, ought to be stored in hogsheads or in a cistern constructed for the purpose. There the solid matter is deposited, and the clear liquor floats above. This liquor may be profitably employed in succeeding operations to dilute the mash. It is found that this practice has the advantage of bringing to the

* Some distillers attribute to chaff properties somewhat analogous to those of malt; that is to say, in giving lightness to the materials. Indeed, M. Dubrunfaut has ascertained that if it has not the property of saccharifying the starch when made into a paste, it at least renders it more fluid and more readily attacked by saccharifying agents.

fermentation a liquor which still contains fermentable matters which have escaped in the previous operation. This course may be continued through many successive operations, three, four, or even five; and we may obtain by this means as much as 60 litres of proof spirit from a metrical quintal of grain, a result which cannot be obtained by any other process. We should cease to use the clear portion of the spent liquor, when, after many operations, it has become so acid as to injure rather than support the vinous fermentation.

"If we operate with a smaller proportion of water, we cannot follow the same course, or at least it cannot be pushed so far, because in that case the fermentation, requiring three or four days instead of thirty hours, yields a strongly acid spent liquor."

This method, like those spoken of before, necessitates the distillation of pasty or semifluid materials, which, as we know, always furnish an alcoholic product of inferior quality; first, on account of certain principles contained in the envelope of the grain; second, because the mash, when distilled over the open fire, readily attaches itself to the bottom of the still, burns and gives to the product a burnt or empyreumatic flavor which detracts very much from its value. These objections disappear when steam is used, or, better still, with the following, known as the:—

Old English Method—Which consists in treating the grain in a vat with a double bottom, so as to make an extract just as is done in the manufacture of beer.

The grain, consisting of malt and raw rye, being mixed and crushed as for mashing by the French process, a layer of short straw, about two centimeters deep, say about ten kilogrammes, is arranged on the false bottom of the vat; on it are placed about 200 kilogrammes of the crushed and mixed grain.

Then, by a lateral pipe communicating with the vacant space between the two bottoms, 200 litres of water at 35° or 40° Cent. are turned on, while one or two men stir the mass vigorously with a beater for eight or ten minutes. The mass is then left to itself for about a

quarter or half an hour, in order that it may be well saturated with water. This operation is identical with and has the same result as the steeping, which precedes the mashing in the last method described, the only difference being in the apparatus used.

Immediately after this steeping, the workmen resume their beaters, and recommence the stirring, while a new supply of boiling water, 800 litres, is turned on by the lateral pipe. This stirring is kept up about a quarter of an hour, then it is left to stand about an hour. At the end of this time any grain which may have been floating on the surface ought to have fallen to the bottom of the vat, and the whole be covered by a stratum of tolerably clear liquid. A cock, which communicates with the space between the two bottoms, is now opened, and as the upper or false bottom, by its conical perforations and layer of straw, forms a species of filter, all the liquid (wort) runs off and is conveyed to the fermenting vats.

The first extract being completed, 600 litres of boiling water are turned in by the lateral pipe, and the mass is again stirred for fifteen minutes; the mass allowed to stand an hour, the wort is drawn off, as before, and set to ferment. The grain which remains on the false bottom, after these two operations, is sufficiently exhausted of fermentable matters which have been borne off by the water in saccharine form.

This operation, which is a true mashing when well understood and properly managed, proves to a demonstration the effect of this mashing on the grain; it proves, as we have said, that it is a true saccharification.

The liquid which we have obtained, and which has been conveyed to the fermenting vats, is leavened when the temperature has fallen sufficiently, say to 20° or 30° Cent., according to the capacity of the vat; and we thus obtain a liquid free from deposit, which may be subjected to distillation in any kind of apparatus.

If it is found that the grain remaining on the double bottom is not sufficiently exhausted, it may be submitted to the operation a third time.

The Germans follow the same method for the distil-

lation of grain, except that in all cases they malt their grain exactly as is done by the brewer.

If we desire to utilize this process to the best advantage, it will be well to increase the proportion of water in making the wort, or at least to dilute the wort with cold water, so as to increase the quantity of water to ten or twelve times the weight of the grain. The particular advantages resulting from this procedure are as follows:—

1. The fermentation is more complete and more rapid, and consequently less acid. 2. The boiling spent liquor, as it leaves the still, may serve for a new steeping and mashing (instead of water), which will without doubt result in a maximum production of alcohol from a given quantity of any vegetable substance.

The spirit obtained by this method is much purer than that resulting from the distillation of a pasty mash, has an agreeable flavor, and may be distilled from the continuous apparatus of Derosne or Egrot, but requires a greater number of vats, more hand labor, and larger capital.

English Process (*new*).—The process at present in use in England, where the business of distilling has been greatly extended since the great advance in the price of spirits, may be summed up as follows:—

Winter Barley, ...	80 parts.
Pale Malt, ...	10 "
Oats, ...	10 "

The barley is coarsely ground, and the malt prepared with the utmost care. The mixture is stirred in a mechanical vat (mash tun), with such a quantity of water that the fermented must shall contain about six per cent. of pure alcohol by measure (say 600 litres of water to 100 kilogrammes of the farinaceous material treated). The must drawn from the mash tun is cooled in very large backs or shallow vats of iron, or, better still, by circulating in the copper tubes of a cooler surrounded by cold water. This last means avoids the changes which sometimes result from contact with the atmosphere, and yields a profit to the distiller, by saving heat; since the

water warmed by this particular arrangement may be transferred to the boiler which furnishes water to the mash tub.

When the temperature of the must has attained the proper degree (18° or 20°), it is set to ferment in immense vats containing from 180,000 to 200,000 litres, by adding five or six litres of fluid yeast, or two and a half to three kilogrammes of dry yeast to the 100 kilogrammes of material employed; the fermentation is developed very slowly at first, then progressively, and is finished at the end of four or five days.

When the operation has been conducted under favorable conditions, the result is about 28 litres of pure alcohol (29½ litres at 95 per cent.) to 100 kilogrammes of the farinaceous substances employed.

Generally the English distillatory apparatus is of colossal dimensions; there are many which distil 5000 gallons (22,700 litres) per hour, or 120,000 gallons (340,800 litres) in twenty-four hours. The superiority of the English proof spirit is due entirely to the use of such stills; *the greater the capacity of the apparatus, the better the quality of the product.* We are well convinced of the truth of this proposition, and indicate the reasons therefor in the various circumstances of the process of rectification.

It is to be remarked that in England, as in France, it has been observed that broken barley allows the filtration of the must, and oats favor it; while, on the other hand, the flour of rye hinders it, and compels us to decant the liquid after a sufficient rest.

Belgian Process.—Since Holland was separated from Belgium, the legislation of the latter country, on the subject of distilleries, has entirely changed the processes in use up to that time, and created a system used in no other country of Europe.

Thus, says M. Lacambre, while, before the Belgian law of July 18, 1833, it usually required 36 or 40 hours to complete the operation of mashing and fermentation; since this date, the greater number of distillers in Belgium complete the operation in 22 or 24 hours, and

there are some who finish in 18 or 20 hours. This is certainly not for the best, because the product is manifestly diminished by it. This practice is followed because of the heavy tax levied on the mash tuns (one franc to the hectolitre for each 24 hours).

The new law of 1852 increases this tax to one and a half francs, imposing an additional impost on those who complete the mashing and fermentation in less than 24 hours, consequently there are no longer any distillers who finish the fermentation in less that 24 hours, which is really a useful and beneficial result of the last change in the Belgian law.

Almost all of the changes which have been made in the old Dutch process, and which legislators and workmen have commonly called improvements, have had the effect, or at least for their object, to reduce the taxes by either accelerating the operations of mashing and fermentation, or reducing the capacity of all the vessels and apparatus on which taxes were laid. From this it will be easy to comprehend how most of the products of the Belgian distilleries in general, and of the farm stills especially, had diminished in quantity and lost in quality before the law of 1852, which has in some measure improved this deplorable state of things.

In fact, prior to 1852, most of the Belgian distillers conducted their work as follows: They had reduced the quantity of mixed flours used to from 11 to 12 kilogrammes to the hectolitre in the mash tun, mixing with water at 50° or 60° Cent., after which they added enough boiling water to fill the vat to about three-fifths of its capacity, and stirred constantly until the mixture was as perfect as possible. When this second addition of water was well mixed in, the vat was covered and allowed to rest for half an hour; frequently, at the end of twenty minutes, the mixture was stirred anew in order to cool it, and the cooling was hastened by the addition of cold water, or cold spent liquor, resulting from a previous operation, to lower the temperature and the density to the required degree. It was then set to ferment at a temperature so high that the first two periods of the

transformation might be accomplished in 16 or 18 hours at most. Now, from what has been said on the subject of mashing the grain and the alcoholic fermentation, it is evident that the saccharification of the starch could only take place very imperfectly and partially. This has been fully demonstrated in many Belgian distilleries by examining the spent liquor, which, prior to the new law, still contained an appreciable quantity of starchy matter in the form of paste.

Then by conducting the fermentation at too high a temperature, as was and is still generally done in Belgium, the acetic fermentation is soon developed, and converts a portion of the alcohol into vinegar, which causes not only a material loss in quantity, but also in the quality of the product.

In fact, as may be ascertained by means of special rectifications, the fermented materials yield a product which is less pure and agreeable to the taste in proportion to their acidity. But a number of the larger Belgian distillers, being aware of the consequences of accelerating the work too much, do not exceed the limits fixed by the rules of the art, and, consequently, obtain far more satisfactory results than the farm distillers. Thus, while most of the latter obtain only 44 or 46 litres of proof gin (50°) from 100 kilogrammes of grain, the majority of the large distillers, who understand their business and have not too great an interest in hastening their operations and overloading their vats with work, usually obtain from 54 to 56 litres, which is, moreover, as a general rule, of better quality than that produced from the small distilleries in which the whole operation was affected in 18 hours.

New Process Generally Used in Belgium.—I shall now proceed to describe the process in general use in the large Belgian distilleries, where they employ the continuous apparatus operated by steam. They sprout their barley as perfectly as possible, pushing it almost to the same degree as for the white beer of Louvain; then dry it in common kilns, taking care to manage the temperature so as not to discolor the malt. This barley malt is

mixed with rye principally, and in exceptional cases with wheat, more or less damaged, and with a small quantity of oats.

Some distillers also employ crude barley, especially that from northern Europe, which is very heavy and cold;* but these are an exception. Most commonly from 24 to 30 parts of malt by weight are mixed with 76 or 70 parts of rye, which is ground very fine; this mixed flour, into which sometimes 8 or 12 per cent. of oats enter as a component part, is turned into the mash tun in the proportion of 11 or 14 kilogrammes to the hectolitre of the vat, the capacity of which varies from 10 to 30 hectolitres. Before placing the flour in the vat, which we suppose to be of the capacity of 10 hectolitres, there are turned in 30 or 36 litres of cold water and about 270 litres of boiling water; then all the flour is poured in at once, say 120 or 130 kilogrammes; the mixture is then vigorously stirred by an implement similar to that used by the brewer.

When the stirring is finished, that is to say, when there are no more traces of flour, and the mixture is homogeneous (which requires generally 20 or 25 minutes), about a hectolitre of boiling water is added while the mass is actively stirred, in order to distribute the heat as promptly as possible. So soon as the mixture is perfect the vat is covered to effect the *fusion*, as the Belgians say, and it is left to rest for about half an hour; after this period of rest, the mass is stirred up for a moment to put in suspension the solid substances which have fallen to the bottom of the vat, and when the mixture has been effected, which is in two or three minutes, the vat is re-covered and left to macerate anew for half or

* The brown barleys of Sweden and Norway, which weigh 66 or 68 kilogrammes to the hectolitre, are highly valued by the large Belgian and Dutch distillers who work this grain ungerminated, with from one-third to one-half of rye and one-fourth of malt prepared from the barley of the country. As the distillers say, this barley is *cold*, that is to say, its fermentation is neither so tumultuous nor so prompt as that of rye and of oats, but the product which it yields is quite satisfactory, and the gin of good quality.

three-quarters of an hour; after this the mass is cooled a little by stirring it vigorously, then diluted with cold water, if at the beginning of a series of operations, or with cold spent liquor clarified by rest, if the work is already commenced. In either event it is so arranged that the diluted mixture shall be at 27° or 30° C., according to the season, the size of the vat, and the temperature of the apartment. When the vats are of the capacity of 15 or 20 hectolitres, as is most usual in Belgium, and if, moreover, the cellar is well selected, that is, well sheltered from sudden change of temperature, it is cooled, usually, to 28° in summer, from 30° to 32° in spring, and 32° to 34° in winter.

It should be observed, too, that more grain is used in winter than in summer. In the latter season most Belgian distillers who do not use mash tuns with a double jacket, and only use 11 or 12 kilogrammes of the mixed flour to each hectolitre of the capacity of the mash tun, in winter increase this proportion to 14 and 15 kilogrammes.

When the mixture is cooled and diluted as much as .the capacity of the vat will allow, it is ordinarily filled to within one-fifteenth or one-twentieth of the top nearly, or so as not to have the vat overflow during the fermentation. The mixture being cooled and diluted to the point desired, the ferment, previously dissolved in a little worts or tepid water, is added in the proportion of 160 or 200 grammes of yeast, in paste, to the hectolitre of the material of the operation. The ferment is well stirred into the mass, the vat covered, and the mass left to ferment quietly until it has reached the *maximum* of effervescence, which happens generally twelve or thirteen hours after the yeast is added. If at this time the fermentation is found to be too active, the cover is slightly raised, so as to cool the mass a little at the surface, and thus render the action less tumultuous; but it would be preferable not to be under the necessity of having recourse to this expedient to which the Belgian distillers, both great and small, are too much addicted. Nevertheless, when the fermentation is pressed

so hard as to become as tumultuous as a liquid in active ebullition, as happens with those distillers who use 14 or 15 kilogrammes of flour to the hectolitre of water, it is well, by any means whatever, to moderate the action, but it would be better, as has already been said, to cool the mass by means of cold water circulating in an interior coil, as is generally done in England, or, better still, by means of a double jacket. This last means is preferable for those distilleries where the natural grain is fermented, that is, without separating the solid parts which render the washing of the fermenting vats very difficult if they contain coils. Moreover, these interior coils render it very difficult to mix the flour thoroughly with the water when this operation is performed in the fermenting vats, as is still generally the case.

When the fermentation does not appear to be sufficiently active the mixture is stirred for an instant, by raising the solid matters from the bottom and plunging the cap into the fluid, that is to say, the solids which float on the surface; the vat is then covered until the fermentation ceases entirely.

A great number of the Belgian distillers infer that the fermentation is sufficiently advanced when the cap has subsided for a couple of hours, but there are others who, less impatient and more enlightened, prefer to pay a little more into the public treasury and wait until they no longer hear any sounds on applying the ear to the wall of the vat. Better still, and this sign more easily determines with exactness the end of the fermentation, they remove the scum and other substances that float on the surface of the liquid, and when no more, or very little foam is formed, that is to say, when bubbles of gas are no longer disengaged in appreciable quantity, they proceed immediately to the distillation; they empty the fermenting vat into a lower vat, and begin at once to transfer the worts to the wine-heater, or forwarding vat when it is used, as is generally the case in all large Belgian distilleries.

As to the method of conducting the distillation in

Belgium, it varies, of course, with the apparatus used as everywhere else, but there is no peculiarity about it requiring special mention here.

Chemical Process.—The saccharification of grains by replacing malted barley by sulphuric, muriatic, or other acids, was, for some years, practised in France. This process, which produces an excellent spirit of very fine flavor, is not adapted to agricultural distillers, because of the necessity of saturating the residuum with lime, which, instead of producing a marc suitable for feeding cattle, is only fit to be cast on the manure pile. Besides, the decree of November 10, 1857, forbids the use of this process in France. We will, however, give a sketch of the process which was employed in large manufacturing distilleries.

The barley or unground rye was set to steep twenty-four hours in advance in twice its weight of water, containing 2 per cent. of sulphuric acid at 66°. At the end of this time the grain thus softened was crushed by being passed between two cylinders; it was then conveyed to a special vat where the saccharification was effected by the assistance of a jet of steam kept up for twelve to sixteen hours, until it was ascertained by means of the *iodine test** that the saccharification was more or less complete.

This operation completed the acid was saturated by the addition of chalk (carbonate of lime), and the liquid suffered to rest for ten or twelve hours; to hasten the precipitation and the cooling, the saccharified material was drawn off into a very broad but shallow back (vat) situated below the saccharifying or steeping vat. The precipitation accomplished, the clear liquid was drawn off into the fermenting vats to be diluted with cold water so that it should contain about ten per cent. of the grain, and the temperature was lowered to 22° or 24° C. in order that it might be leavened (yeasted) in a satisfactory manner.

The deposit of sulphate of lime was washed a number of times with five or six times its volume of water

and the liquid drawn off to serve for a new saccharification, or for diluting the saccharine solution in the fermenting vats.

Some distillers avoided the inconvenience of the deposit of the sulphate of lime by using muriatic (hydrochloric) acid instead of the sulphuric, taking double the quantity, which, by saturation with lime, formed a soluble compound (chloride of calcium) which produced no precipitate.

When ground grain was used the dose of acid was increased one-third, and the time of steeping reduced one-half, that is to say, to twelve hours.

The saccharification of grain by means of acids is much less easily effected than that of flour, because the acid liquid finds much difficulty in penetrating the starch cells. It was on this account that it was necessary to continue the action of steam for a longer time than was necessary for the saccharification of grain in the form of flour.

Alcohol from Rice.

Rice, like all other seeds, is saccharified by means of malted barley, and may be treated by the same methods; but the saccharification is much more complete when, like other cereals, its starch has been converted into a paste. The following is the process usually followed, viz :—

500 kilogrammes of rice, reduced to flour, are mixed with 50 hectolitres of hot water, at the temperature of 60° or 65°, in a vat having a double bottom, perforated with holes; this mixing, which may be effected by hand or a mechanical stirrer operated by steam or other power, being complete, the mass is heated to 70° by steam. This temperature must be kept up, but not exceeded, for half an hour. After this delay, the temperature is reduced to 50° by the addition of cold water, and 125 kilogrammes of ground malt, which are distributed carefully and uniformly, so as to produce a complete mixture. The vat is then covered and suffered to stand

for two hours in order that the saccharification may be accomplished.

The clear liquid is then drawn off into the fermenting vats, and the temperature reduced to 22° or 24° with cold water, and the yeast added in the usual way.

This method in which if a large quantity of water is used, produces the most alcohol, and possesses, too, the additional advantage of the greatest simplicity.

Alcohol from Potatoes.

Analysis of the Potato.—Independently of the water it contains, the potato consists mainly of starch and a fibrous substance which is very similar to starch.

100 kilogrammes yield as an average:—

Dry Starch	16	kilogrammes.
Parenchyma	9	"
Water of Vegetation	75	"
	100	"

The parenchyma and water in their turn contain various substances, viz: cellular tissue, pectose, pectin, albumen and nitrogenous matter, sugar, resin, essential oil, fatty matter, citrate of potash, phosphates of potash and lime, silica, alumina, oxides of iron and manganese.

Selection of Potatoes.—On account of their size, some potatoes are to be preferred for the manufacture of alcohol or starch, and for fattening cattle, while others, on account of their flavor, are employed as food for man. The varieties are multiplying daily, and each locality has its own. The qualities of soil and the peculiar methods of culture are infinitely varied, and this vegetable is undergoing so many modifications that, before a great while, it will be almost impossible to recognize its original characteristics.

The starch, however, is the portion which it is important to consider in this connection. Its quantity varies much in different species of the potato, according to the nature of the soil in which it has grown, the temperature of the season, their state of preservation, &c. &c. They

contain most, just after being harvested. The best potatoes, that is, those which contain the most starch, and which, consequently, are most mealy when cooked, yield also the most alcohol. Those which are diseased, sprouted, or damaged, yield only a small quantity, and that holds in solution a principle having a bitter and disagreeable flavor. Winter is the best season for distilling potatoes, that is, from the beginning of October, when they are harvested, to the latter part of March, when they begin to sprout.

Potatoes will not bear extremes of temperature. They should be stored in cellars or store-rooms protected from the vicissitudes of the weather, and should only be taken out as needed for use. It is, however, not important to reject those which may be frozen, since it is only the water of vegetation which is attacked; the starch and parenchyma may be separated from it. It suffices to place the potatoes in cold water until they have acquired sufficient firmness to be subjected to the action of the rasp.

Testing the Quality of Potatoes.—To ascertain the exact quantity of starch which is contained in any given variety of potato, we first remove carefully with a brush all the earth adhering to the surface. The tuber is then cut in very thin slices, which are spread evenly and side by side on a plate, care being taken to avoid overlapping; they are then dried either in a current of heated air, or in a stove heated to 40° or 50°. It is known that they are perfectly dry when, after repeated weighings at intervals of three or four minutes, the slices are found to lose no more weight. The slices are then hard and brittle. Deduct nine per cent. of the original weight for the parenchyma, and the remainder will indicate the quantity of starch.

In making this test it is not a matter of indifference whether the tuber is cut near the middle or at the outside, because the starch is not distributed equally throughout all parts of the root. It is found in greater proportion near the outside than towards the middle. This in large

potatoes is sometimes almost transparent, and contains little more than water and tissue.

Potatoes may also be tested by reducing them to a pulp on a small tin rasp and extracting the starch, which is then dried, and the weight indicates the value of the root.

Processes for Distilling Potatoes.

There are three methods of preparing potatoes, previous to subjecting them to alcoholic fermentation:

1. By cooking.
2. By rasping.
3. By the saccharification of the starch green or dry.

These methods have but one end—to saccharify the starch, either by means of malted barley or of acids.

Distillation of Cooked Potatoes.

This method consists of five distinct operations:—

1. Cooking the potatoes.
2. Reducing them to pulp.
3. Mashing, or saccharifying by means of malt.
4. The alcoholic fermentation.
5. The distillation.

Each of these operations will be described in order and as rapidly as possible.

Cooking.—The potatoes, after having been well washed, should be cooked by steam in a cylindrical vessel. A hogshead properly arranged will answer. The apparatus described by Dombasle appears to be perfectly adapted to this purpose. It consists of an iron boiler set in masonry, the upper surface of which is well covered with good mortar, and rises with a gentle inclination above and from the edge of the boiler. Upon this masonry is a hogshead with the upper head removed (or a special vat made of stout oak staves), the bottom of which should have a diameter eight or ten centimeters greater than the boiler, in order that the hogshead may stand firmly on the masonry. The bottom of the hogshead, which should be of thick wood, is perforated with

a great number of holes ten or twelve centimeters wide, and fifteen centimeters long, to give passage to the steam. They should not be round to avoid the accident of being closed by the tubers fitting into them.

To facilitate the operation, the hogshead should have an opening near the bottom, closing by a door, through which the potatoes are to be drawn out when cooked, without displacing the hogshead. If the locality will permit, the potatoes should fall directly from this opening into the hopper of the crushing mill.

It commonly happens that there is some escape of steam below the hogshead where the *chime* rests on the masonry; this is easily stopped by a lute made of clay and horse dung. The hogshead must not be completely filled, as the potatoes swell considerably in the course of the operation.

Reducing to Pulp.—As soon as the potatoes are sufficiently cooked they are placed in the hopper of the crushing machine, to be reduced to a homogeneous pulp. This machine commonly consists of two cylinders of oak, which by their friction crush the potatoes and reduce them to the condition of paste.

Mashing or Saccharifying by Malted Barley.—When the potatoes have been reduced to a paste, the *mashing* is at once conducted almost in the same manner as for grain. Taking 1000 kilogrammes, for example, the process is as follows:—

The paste is arranged in a vat of the capacity of 35 or 40 hectolitres, to which are added 70 kilogrammes of broken malt, and such a quantity of hot and cold water as to bring the temperature of the mass to 36° or 42° Cent., in order that the steeping of the malt may be properly accomplished. Care must be taken to stir the paste and malt with a fork as the water is gradually poured into the vat, and hermetically close the vat as soon as the stirring is finished. After a rest of half an hour boiling water is added until the whole has acquired a temperature of 60° Cent., and the mass is left to macerate three or four hours.

Fermentation.—When the *mashing* is completed the

mixture is increased by alternate doses of cold and boiling water until the quantity is made up to 32 or 35 hectolitres, according to the size of the vat, and in such a manner as to establish the proper temperature (24° or 26° Cent.). This point reached, two and a half or three litres of good liquid beer yeast, or two kilogrammes of dry leaven are added. The fermentation is soon under way, and follows the same course as that for grain.

Distillation.—Potatoes, by reason of the pasty nature of the material resulting from this method of cooking, should be distilled in the apparatus discussed on pages 73 and following (in Figs. 4 and 5, Pl. IV.), or in some simple apparatus worked over the naked fire; the latter is best adapted for agricultural establishments.

1000 kilogrammes of potatoes treated as above with 70 kilogrammes of malt will yield an average of 160 litres of spirit (or 74 litres of pure alcohol) at 46° having an unpleasant odor.

Distillation of Potatoes by Rasping and Maceration.

The object of this process is on the one hand to avoid the expense of cooking the potatoes, and on the other the manual labor indispensably necessary, in separating the starch. The process is as follows:—

1000 kilogrammes of potatoes reduced to a pulp by means of the rasping machine are placed in a vat of 22 to 25 hectolitres, and with a double bottom, on which are spread evenly 25 or 30 kilogrammes of short straw. In this position the pulp is allowed to drain for about half an hour to deprive it of a portion of its water of vegetation, which is drawn off from time to time by a cock placed between the two bottoms. After this delay 1000 or 1200 litres of boiling water are added gradually, and then 70 kilogrammes of malt previously steeped, while two men stir the whole vigorously.

After a maceration of three or four hours the clear liquid is drawn off by the cock under the false bottom, and the mass suffered to drain ten or fifteen minutes. The liquid so drawn off is conveyed immediately to the

fermenting vat. In the mean time, 500 litres of boiling water are turned on to the pulp—it is stirred anew—the liquid drawn off as before, and turned in the fermenting vat with the first.

Finally, the potatoes are entirely exhausted of fermentable principles, and at the same time a proper temperature is given the liquid to be fermented, by the addition of a third charge of cold water, which, after being stirred and drawn off as before, is added to the product of the two previous operations.

The liquid resulting from the three operations just described is set to ferment by means of liquid beer yeast in the same proportion and manner as for the must of grain, or by 2½ or 3 kilogrammes of dry leaven to the 1000 kilogrammes of potatoes.

By this process is obtained quite a large quantity of residuum (marc), which is excellent as food for cattle; there is no pasty material to distil, the must is quite clear, and a quantity of spirit drawn off is superior to that produced by the preceding process. It has, too, a better flavor and odor.

Employment of the Residuum from the Distillation of Potatoes.—The residuum resulting from the two processes just described by reason of its pasty nature constitutes an admirable article of food for cattle, but which, however, after prolonged use may prove too laxative. This inconvenience may be avoided, or remedied, by giving to the animals an addition of ground Indian corn, peas, or beans, or, better still, oil cake, &c.

Distillation of Potatoes by Saccharifying the Starch.

Potato starch is a pulverulent substance without taste and odor, which drains off with the water of vegetation, and which is separated from the tubers by means of many operations, the principal of which are the rasping of the tubers and the separation of the starch from the parenchyma when the potatoes have been washed and reduced to a fine pulp by means of a rasp; this pulp is placed on a sieve of hair, or metallic cloth. The pulp is well rubbed

between the hands to mix it with a stream of water which flows on to the middle of the sieve and carries off all of the starch set free by tearing the fibrous tissue of the cells which make up the substance of the root. The liquid flows through the sieve in a state of limpidity. When all the starch has been exhausted from the pulp, the waste material is thrown aside and a new supply of pulp placed on the sieve, and so on. The starch is obtained suspended in the water, and after a little while falls to the bottom of the vessel; this deposit is then mixed with fresh water and allowed to deposit two or three times successively, changing water each time; it is laid up to drain on cloths, and if it is desired to preserve it, the mass is dried in the open air, or in a drying room.

In modern starch factories manual labor is reduced to a minimum by the use of a continuous apparatus in which the washing and rasping of the tubers as well as the washing of the pulp on the sieve is effected by machinery.* They easily treat 160 hectolitres of tubers in ten or twelve hours, and obtain 16 or 17 per cent. of dry starch. The exhausted pulp retaining 2 or 3 per cent. of starch, which cannot be removed by the most energetic washing, is used as food for cattle.

Green starch, that drained but not dried, and dry starch, must, in order to produce alcohol, be first converted into sugar by the process of saccharification either by the assistance of malt or sulphuric acid.

Saccharification by Sulphuric Acid.—The following is the process by which starch is saccharified on a large scale for the manufacture of alcohol:—

To perform this operation a special vat called a saccharifier is used; a description has been given before, as well as a drawing. (Fig. 2, Pl. VI.) It is filled to about two-thirds with acidulated water (6000 litres of water with 40 kilogrammes of sulphuric acid at 66°). The temperature of this water is then raised to 100° C. by

* For a particular description of the very ingenious machine used in this manufacture the reader is referred to Muspratt's Practical Chemistry, vol. ii. pp. 953 et seq.—*Trans.*

steam through the pipe *c*, which is connected with the generator.

The vat being prepared, 2000 kilogrammes of dry starch are taken and mixed in quantities of 100 kilogrammes in a tub with 100 litres of water, the starch mixture is then poured into the funnel *d*, in small quantities of 15 or 20 litres at a time, the ebullition of the mass being kept up until the whole 2000 kilogrammes having been turned in, and the decomposition is complete, which happens about an hour after the last addition of starch.

The starch in this operation passes first into a pasty state, then becomes fluid, and is converted into gum or dextrine, and is then transformed into glucose in the form of syrup. It is ascertained that the starch is entirely saccharified, and that the mass contains no more gum by taking a little of the liquid in a champagne glass, mixing with 3 or 4 parts of alcohol (90°); if the liquid contains any gum, it will be precipitated in white flocks; if there is no gum present, it is an evidence that the saccharification is complete. A few drops of tincture of iodine poured into the cold mixture without producing a violet tint indicates that the operation is completed.

The steam is now cut off, and we proceed to the separation of the sulphuric acid from the saccharine principle, by saturating the liquid with chalk or Spanish whiting (carbonate of lime). For 40 kilogrammes of sulphuric acid we use 45 or 50 kilogrammes of carbonate of lime mixed to the consistency of cream with a little water, and thrown into the vat in small quantities at a time. At each addition of the carbonate of lime through the man-hole *f*, a strong effervescence is produced by escape of the carbonic acid gas, which may throw the liquid out of the vat if the additions are not carefully made.

It is ascertained that the saturation is complete by the cessation of the effervescence, and more accurately still by means of litmus paper, which is no longer reddened by contact with the liquid. When the operation

is finished the liquid is allowed to stand twelve hours in the same vat or another, then the clear part is drawn off into the fermenting vats. The deposit left in the vat is sulphate of lime (gypsum), a substance of little solubility.

A more highly acidulated liquid will render the saccharification more prompt; but, on the other hand, it will be necessary to increase the dose of carbonate of lime, which may injure the solution and prevent its clarifying. The dose indicated (two per cent. of acid) has been recognized for a long time as that which produces the best results.

The arrangement of the flue *e* which conducts the vapors from the vat into the chimney (stack) prevents the disagreeable emanations which result from the process of saccharification. The essential oil of starch concondensed with the water flows into a vessel arranged to receive it. During the operation the vat should be covered so as to direct the vapors into the flue, and prevent their condensing on the walls and ceiling and running down in dirty streaks.

The pressure of steam proper for the operation of saccharification should be two or three atmospheres, because the more active the ebullition the more quickly will the starch be converted into the saccharine principle. It is unnecessary to stir the liquid, as the steam agitates it quite enough for the success of the operation.

During the saccharification of starch by sulphuric acid there is neither absorption nor evolution of gas; the atmosphere produces no effect whatever; the sulphuric acid is unaltered; finally, 100 parts of dry starch produce 110 parts of dry sugar. In the factories are obtained from 100 parts of dry, or 150 parts of moist starch, 150 parts of syrup of 30° representing 100 parts of solid sugar.

To explain these remarkable results, M. Theodore de Saussure thought that under the influence of the acid which destroyed the starch cells and set the dextrine free, the latter appropriated to itself a portion of the

elements of the water, and that consequently the sugar was formed by a combination of dextrine and water. Chemical analysis demonstrates, in fact, that glucose differs from starch and dextrine only in this, that it contains a little more oxygen and hydrogen than these last, and exactly in the proportions in which these two elements exist in water. The composition of these three substances may be represented thus :—

	Starch and Dextrine.	Glucose.
Carbon	43.81	36.80
Water, or its elements . .	56.19	63.20
	100.	100.

From which it is seen that glucose only differs from starch and dextrine by containing 7.01 parts of water, or its elements.

The saccharification of the starch of different grains by sulphuric acid is effected in the same manner as described for potato starch. The use of hydrochloric acid presents the advantage of producing on one hand quite a pure alcohol, and on the other a residuum which when neutralized by soda, may serve to a certain extent as food for cattle.

Saccharification by Malt.—This operation, the only one used at present, is conducted almost in the same manner as the preceding; only the sulphuric acid is replaced by malt. Chemists have ascertained that malted barley, like all other seeds in a state of germination, contains a peculiar principle soluble in water, neutral, and not crystallizable, which they call *diastase.*

The following is the process for saccharifying 500 kilogrammes of dry, or 750 kilogrammes of green starch by malt.

The starch is mixed in a vat of 30 hectolitres with 1000 litres of cold water, taking care to agitate the whole continually to maintain the starch in a state of suspension and prevent it from precipitating.

There are added gradually 1700 litres of boiling water. The mass at first thickens and is converted into a paste; but in proportion as the boiling water is poured in, its

milky appearance disappears to give place to a most remarkable transparency. At this moment, 75 or 80 kilogrammes of malt, reduced to flour, to favor still more its action on the starchy solution, are added, as is done in the saccharification of grain. The whole is stirred vigorously for ten minutes, then the vat is closely covered and allowed to stand three or four hours; during this time the diastase contained in the malt acts upon the starch, and transforms it completely into saccharine matter.

The Fermentation.—The saccharine liquid obtained by either process of saccharification just described, may be transferred to the fermenting vats without being filtered; then a certain quantity of water (cold or hot, as may be necessary) is added, so that the temperature may be at 22° or 24° Cent., and the solution shall mark 7° by the areometer of Baumé. These arrangements completed, 1 litre of good fresh yeast, or 500 grammes of dry yeast to the 1000 litres will be sufficient to start the fermentation, which progresses very regularly, and is usually terminated in 36 hours.

Distillation.—The fermentation being finished, the liquor is allowed to rest 24 hours, then the distillation is proceeded with in a continuous apparatus.

The alcoholic result is in proportion to the more or less perfect saccharification of the starch. But generally, 100 kilogrammes of the latter will produce 35 or 40 litres of pure alcohol, or from 40 to 45 litres of spirit at 95°.

The product will be sensibly increased if the spent liquor be used in succeeding fermentations, as is practised with grain and molasses.

The spirit from starch is very fine and of excellent flavor. It may be used for all purposes to which the trois-six of Montpellier is usually applied; but its greatest merit is that of improving the latter; in fact, if two parts of the trois-six of Montpellier be mixed with one part of fine starch spirit, the product will be preferable to the pure Montpellier, because it will have acquired an extraordinary delicacy.

Remarks on Spirits from Grain and Potatoes.

The spirits produced by these substances possess an odor and taste called *fusel*, due to peculiar oils of a nauseous odor, analogous to the essential oil of wine or œnanthic ether. These substances are produced during the fermentation of the must. They exist already formed in fermented liquors, since they distil with the alcoholic vapor when the mixture is simply heated. The spirit which is manufactured from syrup or starch prepared by means of sulphuric acid is perfectly free from essential oil. This last, then, is produced by the alteration of the albumen, or some other nitrogenous principle of the potato, which takes place during the fermentation.

The essential oil of grain spirit is composed in great part of a non-etherizable fat acid, which in composition approaches œnanthic acid, but which nevertheless differs from it in some of its properties. The oil of potato spirit, which was first noticed by Scheele, is analogous to ether. It is excessively acrid, and its vapor provokes coughing and even vomiting.

It should be observed that spirit produced from flour of grains, from which the bran has been separated by bolting, has a far purer taste and odor than that resulting from flour which has not been subjected to this operation; because it has been known for a long time that it is the envelope of the grain that contains the peculiar essential oil which causes the bad flavor of this spirit.

Potato spirit extracted directly, that is, without subsequent rectification, often acts in a most deleterious manner on the animal economy, either because it contains some acid or volatile principle, or because it contains solanine and prussic acid, as a great many chemists have stated.

Alcohol from Sorghum, or Chinese Sugar-cane.

The sorghum, or Chinese sugar-cane (*Holcus saccharatus*), a plant cultivated in the northern parts of China, was sent, about the year 1850, to the Geographical

Society by M. de Montigny, the French consul at Shanghai. This society introduced the seed into France, and aided by the indefatigable zeal of the society of acclimatization, encouraged a serious examination of its properties. The seeds from this package were, in the first place, experimented on by one of the most eminent members of the commission at Toulon, and since then many others have ardently turned their attention to the cultivation of this plant. We then saw it spread over the whole South of France, in Bordelais, Champagne, Sologne, and even to the vicinity of Paris, where it excited the greatest emulation among the most distinguished agriculturists. At present the cultivation of sorghum is extending itself more and more, especially in Algeria. That country is most favorable for its culture, especially in the plains of Matidja; for a moist heat is necessary for this species of plants.

About the same time that Montigny gave this important bequest to France and its colonies, Leonard Wray discovered in Africa, among the Zulu Caffres, many other varieties of sorghum, cultivated for their sugar and confounded by the public under the name of *Imphee*, and even by some mistaken for the Chinese variety. Wray had an experienced eye to the part Imphee might take in the agriculture of tropical countries, and he made persevering researches into the subject in the English Antilles and at the Cape of Good Hope.

Such is the history of sorghum; doubtless many varieties are confounded under the same name; cultivation on a large scale only can decide which is the best. Notwithstanding this inevitable confusion, great results have and will continue to be obtained.

Sorghum grows promptly; five months in fact are sufficient for its complete growth all along the shores of the Mediterranean. We can only hope for a single crop in one year, but we cannot expect the bountiful production of the tropics in our climate; yet even in its less favored position sorghum offers the promise of more sugar and alcohol to our factories, and more forage to the farmer, than is afforded in the same time by the beet crop.

Sorghum should be planted according to the varying circumstances of the season and the climate. In France it should be manifestly later than in Algeria. In the latter country the seed time is from April to June. In France the seeding should commence as soon as there ceases to be any expectation of frost.

The cultivation of sorghum is easy and not attended with any considerable expense. It is only necessary that the soil, without being wet, should continue somewhat moist during the earlier period of its development. It is proper to shelter the young plants from a too-great heat of the sun, which may be accomplished by sowing some other plant of more rapid growth, between the rows. The hills should be about 60 centimeters apart each way.*

It does not appear to require very heavy manuring, guano seems to suit best. Frequent ploughings are indispensable to its rapid growth. Throwing the earth up to the plants also favors their development. When it has attained its maximum of growth, sorghum is a slender plant, rising three or four meters, and even more on rich land, in straight thin stalks, with flexible and drooping leaves; its appearance is quite like Indian corn, but it is more beautiful. It forms generally a cluster composed of five or six stalks, terminated by a conical panicle covered with flowers, green at first, then passing through the various tints of the violet to a deep purple at maturity.

Sorghum is harvested when the seed is perfectly ripe; that is to say, when it is of a decidedly chestnut color. The plants are cut with a *bill*, then conveyed to the barn or factory, where they are to be consumed. The leaves are stripped off and the tops removed.

It has been ascertained that not more than two or three stalks should be left in a hill; if there are more, the stalks will be slender and will contain relatively less juice, and will be rejected by the distiller.

* American farmers have found that a greater width between the rows is preferable, as giving room for the use of the plough as well as affording space for a larger growth of cane.—*Translator*.

When the cane is left standing beyond a certain time there will be serious loss, because towards the end of November there is developed in the interior of the cane the larva of an insect, which feeds on it at the expense of the saccharine matter. It is also known that sorghum, when cut and allowed to stand in stalks for some days before it is used, loses a portion of its juice, and that the sugar begins to ferment. It is important then to avoid these sources of loss, to harvest the cane as soon as it matures, and use it immediately.

The product of the sorghum consists in the juice abundantly contained in the pith of the stalks, but the richness in sugar diminishes in the joints as we approach the top of the stalk, where the tissues more recently developed are more watery. This juice stands between that of the true sugar-cane, lacking the aroma, and that of the beet in lacking its disagreeable odor. It therefore produces alcohol devoid of taste when carefully rectified. It has also been observed that the juice of sorghum contains a natural ferment, which may serve in case of necessity to start the fermentation and transform the saccharine matter into alcohol.

The saccharine richness of sorghum juice has been the object of a number of analyses, from which it has been determined that this richness varies from ten to twenty per cent.

The earliest method in use for obtaining alcohol from sorghum is that of M. Count David de Beauregard, President of the Agricultural Society at Toulon. It consists in subjecting the cane, stripped of their leaves, to the powerful action of a rolling mill, consisting of three cast-iron cylinders placed horizontally, as is done with the true cane in America. The method requires a great motive power on account of the necessity of bringing the cylinders very close together to prevent the loss of juice. By this means only one hectolitre of juice to the horse power is obtained in one hour.

This juice or syrup is set to ferment, without being heated, by the addition of a small quantity of dry yeast (about 50 grammes to the hectolitre), and under the in-

fluence of the surrounding temperature alone. After this fermentation has run its course, and is entirely terminated, the liquor is distilled.

The method of working, which requires a considerable outlay at the start, and which demands the use of many horses or of steam-power, cannot be adopted in small agricultural distilleries. It has, besides, the objection of only producing the average of 3.75 or 4 litres of alcohol to the 100 kilogrammes of cane.

There is another method which consists in pressing the canes as above, and then macerating in water the bagasse which still contains a considerable quantity of saccharine matter; then, when the fermentation is finished, uniting the liquid resulting from the maceration of the bagasse to that from the mill and distilling, the two in the usual way.

Some colonists in Algeria content themselves with crushing the stalks of sorghum, and macerating the whole with cold water, without the addition of any ferment whatever, in a hogshead standing on end, in open sheds exposed to all the viscissitudes of the weather.

Some persons operate after the method of M. Leplay or M. Pluchard, *i. e.*, by direct distillation of the sorghum. Our opinion is sufficiently set forth in the article on the subject of the distillation of the beet, and we may dispense with any further reference to it here. It may be well understood that the spirit obtained by either process is of inferior quality.

But of all methods used for the distillation of sorghum, the process of maceration by heat is without contradiction the best. It is, moreover, that which we have employed at Settimello (Italy), and at the large distillery of Amor-el-Ain, near Blidah (Algeria). It is managed as follows, viz:—

The stalks of sorghum, stripped of leaves and the tops, are cut in short pieces by means of a sorghum cutter. It consists of an iron cylinder armed with eight or ten steel blades arranged obliquely in connection with a pair of feed rollers, one of which is plain and the other grooved, so that the stalks are pressed forward as

they are cut. When a sufficiency of material is prepared, the cut stalks are placed in a macerator, No. 1, then covered with boiling water, or cold water, which is heated to 80° by means of a jet of steam. After an hour of maceration, this liquid is drawn off in a macerator, No. 2, where it remains one hour.

The operator should introduce into the second maceration one part of sulphuric acid [at 66°], to the thousand, diluted with twenty times its weight of water. The liquid is now drawn off into a macerator, No. 3, where it stands one hour. This last maceration completes the saturation of the liquid with the saccharine juice.

When the routine of work is well established, the juice drawn from the second maceration is always used for macerating fresh cane, during which it is more freely charged with saccharine matter. When drawn off from the cane the liquor is allowed to cool, so that it may reach the fermenting vat at a proper temperature. The second charge is made with the weak liquor, resulting from a third maceration; and the third charge is always made with pure boiling water (or heated, as has been described).

On leaving the macerators, the concentrated juice, as it reaches the fermenting vat, should have a temperature of 20° or 25° at most, and should mark an average density of 6° by the areometer of Baumé. Under these conditions, the first operation of maceration furnishes the liquor in which to dissolve the liquid leaven necessary to start the fermentation according to the capacity of the fermenting vat. The proportion used is 25 litres of fluid yeast, or 120 grammes of dry to the hectolitre of juice. This is called the "*bottom of the tub*."* When this *bottom* is in full fermentation, which commonly happens one hour after its preparation, the vat is filled successively with the liquid resulting from new macerations.

The fermentation always progresses regularly, and is finished without violence; it is completely, terminated in 18 or 20 hours, and rarely extends to 24 hours. The

* Footing.—*Trans.*

froth is white and light, and does not require the use of any fatty substance to cause it to fall.

After a rest of 24 hours, the fermented juice or wine of sorghum is subjected to distillation in the apparatus of Egrot, Derosne, or some other, and yields an average of five litres of alcohol at 95° to 100 kilogrammes of the sorghum cane.

The system of maceration by steam which we described in the article on Beet Spirit, may be applied as well to the treatment of sorghum.

Towards the close of the season, it sometimes happens that the sorghum juice contains so great a quantity of acetic acid produced by changes within the stalks, and even lactic acid, that it becomes necessary to saturate the juice with lime to obtain a successful fermentation. It is not important, however, to have this saturation too perfect, indeed it is better to preserve a slight acid reaction, lest too great a degree of alkalinity may interfere with the success of the fermentation. The juice so saturated should only be employed after being drawn off clear and separated from the deposit resulting from the saturation.

The distillation of the sorghum left standing and cut as required is not profitable after the month of January [in France.] After this time the cane dies, is heated, ferments, or is destroyed by larvæ, as has already been said, which devour all the pith, and with it the sugar, and leaves absolutely nothing more than the external envelope.

Apparatus of M. B. Viale.—Now that we have described the various methods in use for obtaining alcohol from sorghum, we think it will not be amiss to speak of an apparatus which is readily set up in agricultural establishments, and which is used for the extraction of the saccharine juices contained in sorghum, beets, artichokes, etc. etc.

The following is a description of this apparatus. (See Fig. 7, Pl. VI.)

A. Tubular pan for concentrating the syrups.

B. Chimney.

C. Apparatus for boiling the sorghum cane or other substance.

D. Stopcock for drawing off the juice.

E. Furnace.

The furnace is so constructed that the smoke on leaving the boiling apparatus traverses the tubular pan A, and returning by the two sides finds its way to the chimney. It is easy to understand the economy of this arrangement in utilizing the waste heat.

The manner of extracting syrups by this method is as follows: The stalks of sorghum stripped of leaves are cut up by means of a stalk-cutter, and as cut, are placed in the boiling apparatus, care being taken to place a wicker-work hurdle on each layer of 15 or 20 centimeters. When the apparatus is filled with cut sorghum, it is filled with water enough to cover the cane, then for each 100 litres of water in the apparatus are added 200 grammes of sulphuric acid. It is then boiled for twenty minutes; the syrup is now drawn off by the cock, the bagasse being at the same time pressed by the screw fixed above the boiler. The juice is then poured into the tubular pan to be evaporated to the proper degree of concentration (20° or 25° is generally enough).

The boiler is then emptied of bagasse by the assistance of a fork, and a second operation begins.

Syrups prepared in this way are only fit for distillation, and may be bought by the distiller at the same price as molasses from the beet.

The following is the method adopted by M. Viale for ascertaining the true value of such syrups and thereby fixing the price.

We know, says he, that molasses is sold at 40°, and by the 100 kilogrammes. Let us suppose a cask of sorghum syrup contains 160 kilogrammes at 25°; this is the product of 1000 kilogrammes of cane; we will multiply 160 by 25, which will give 4000; divide 4000 by 40, and we find the true quantity of merchantable molasses 100 kilogrammes; this is sold according to the

price of alcohol. July 30, 1857 *trois six* was worth 118, and beet molasses 26 francs per 100 kilogrammes. Then we find the value 26 francs per 1000 kilogrammes of cane with 200 kilogrammes of forage over. The hectare yielding upwards of 50,000 kilogrammes of cane will produce 1500 francs to the farmer. The cost of extracting the syrup from the sorghum may be estimated at a maximum of 5 francs for 1000 kilogrammes of stalks, which will cause a deduction of 250 francs to the hectare; there will remain then 1250 francs, which is a heavy yield as compared with other crops, while over and above the syrup, each hectare produces 30,000 kilogrammes of forage.

If it is desired to fit these syrups for table use, it is necessary to saturate them with Spanish whiting and clarify them with animal charcoal.

The syrup of beets is extracted as follows:—

The beets cut in thin slices by means of a root-cutter are cast, as they are cut, into a copper containing 200 litres of water and one kilogramme of common salt. When these slices have been macerated for about ten minutes, they are withdrawn from the copper and dripped, and are then thrown into the boiler *c* in layers of about 25 centimeters, being careful to lay a wicker hurdle on each layer. When the apparatus is full, the block which serves as a part of the press is put in place, and the whole carefully covered with a moistened cloth; the fire is then kindled under the boiler, into which have previously been poured 40 litres of water; this is quite sufficient water to furnish by ebullition, enough steam to cook the slices of beet. When these are cooked the discharge cock is opened, and the press applied; the juice drawn off ought to weigh four or five degrees by the areometer of Baumé according to the richness of the beets. This juice is then turned at once into the tubular pan A to be concentrated to a syrup, marking 22 or 25 degrees of the areometer of Baumé. In this form it may be put in hogsheads and preserved during the winter.

The succeeding operations are conducted in the same way, with this difference, that by refilling the boiler with water there are left forty litres of juice, marking four or five degrees.

The salt water in the copper used for macerating the fresh slices of beets may answer for four or five macerations, and need only be renewed when it marks 4 or 5 degrees; when it may be used in the boiler in place of the 40 litres of water. At the end of the day's work, this, as well as all the juice marking 4 or 5 degrees, should be concentrated to a syrup with the exception of forty litres of water, which may be left in the boiler to recommence the operation next morning.

By this process, according to M. Viale, 1000 kilogrammes of wine yield 130 or 140 litres of syrup at 25 degrees, according to the nature of the beets, and 600 kilogrammes of pulp.

This process of Viale renders it possible for small farmers to make the pulp themselves according to their necessities, and enables them to forward the juice with facility to the distiller in a proper state of concentration. They avoid, too, the transportation of the beets to the distillery, and the return of the pulp to the farm, at a season of the year when such transportation is always difficult.

The Jerusalem artichoke is treated in the same manner as the beet.

The apparatus of M. Viale is readily set up on a farm, occupies but little space, and may be operated by any farm hand. It is so simple as to require few repairs, and is of quite a moderate cost.

Alcohol from the Asphodel.

The asphodel, commonly called in France the king's rod, is a beautiful plant growing in the South of Europe, the tuberous roots of which are reproduced abundantly, according to climate, every two or three years. Its stalk, which rises to the height of about one meter, is

covered in the month of April with a beautiful white or yellow flower. Its leaves, which are very like some varieties of flag, dry up towards the end of summer, to be renewed at the beginning of autumn, and remain green all winter, except when the cold is very severe.

There are many varieties of the asphodel, but the principal are, the branching asphodel (*Asphodelus ramosus*), which appears to be the original type of the plant, and is found growing wild, and the yellow asphodel which is cultivated in gardens. The wild asphodel, which is the variety used for purposes of distillation, is never cultivated, but grows in great abundance on the plains of Algeria, in Corsica, Sardinia, Tuscany, Sicily, Spain, in the South of France, and in fact all along the coasts of the Mediterranean.

The root of the asphodel forms a cluster of fusiform tubercles, brown on the outside, white within, as large as the thumb, and eight or ten centimeters long; stands by analogy between the root of the turnip and the dahlia.

No attempts have been made to cultivate the asphodel, because it requires two or three years for its vegetation, and manufacturers content themselves as if working a sort of mine without troubling themselves about its reproduction. An analysis of the root shows that it contains the following:—

Water, ...	68.84	parts.
Ash, ...	0.75	"
Fatty substances, soluble in ether, . . .	2.20	"
Substances transformable into grape sugar, by the action of ferment, or acid, ...	18.25	"
Pectine, ...	2.30	"
Albumen coagulable by heat, ...	0.42	"
Cellulose, ...	7.00	"
Loss, ...	0.24	"
	100.00	"

The large proportion of principles susceptible of being transformed into alcohol (27.55 parts in 100), found by

M. Marés in this analysis, excites the suspicion that he operated on selected tubers collected under favorable circumstances, because, as we shall see hereafter, we do not in practice obtain such favorable results.

It should be remarked that the roots of the asphodel do not furnish alcohol in abundance, except during the season of flowering, which is in April, May, and June. Before and after this period the quantity of alcohol diminishes, and finally is reduced to nothing.

The distillation of the asphodel, originating at a time when wines and spirits were very dear, appears to have no future. Although it produces alcohol at a very moderate price, since the roots are collected on uncultivated land, where their spontaneous growth enables them to be sold for the cost of collecting (1¼ to 1½ francs for 100 kilogrammes), it is evident that it cannot contend in an abundant season with the wines of the south. The disagreeable odor of asphodel spirit, which it is difficult to remove, even partially, will always interfere with its sale, except when the price of other spirits is very high.

We shall nevertheless examine the different processes used for the extraction of alcohol from the roots of the asphodel.

In the *first process*, the roots are washed to remove the earth adhering to them, then crushed in an oil-mill, or by some special machine, so as to reduce them to the condition of pulp. After this operation, the pulp is thrown into common vats, where it is covered with water and stirred, then set to ferment by adding 200 grammes of dry yeast to 100 kilogrammes of the roots.

After the fermentation, the clear liquor is drawn off and distilled in any kind of apparatus. The amount of alcohol obtained by this method is usually from 3½ to 4 litres at 96° to 100 kilogrammes of the root; but it would be much greater if the material itself were distilled in the vat in which it was fermented, by means of a special arrangement adapted to the use of a jet of steam.

In Algeria there are some distillers who allow the

materials to ferment without the addition of any leaven; this method is objectionable, because the fermentation is developed too slowly, and as a consequence, notwithstanding what certain persons may say, the result is by no means profitable.

By the *second process*, the roots are also washed before being subjected to the action of a rasp similar to that which is employed for reducing beets to a pulp. When this pulp has been submitted to the action of a press (hydraulic or other), the juice, after being heated to 20° or 24°, is poured into a fermenting vat, then 250 grammes of dry yeast for each hectolitre of liquid are added, and the fermentation is very well established. When this is completed, the liquor is distilled, and yields an average of 4½ or 5 litres of alcohol at 96° to 100 kilogrammes of roots.

By the *third process*, the roots, after being washed and reduced to a pulp, as above, are placed in a saccharifying vat with two or three per cent. of sulphuric, or five or six per cent. of hydrochloric (muriatic) acid, and fifty or sixty per cent. of water. In this state a jet of steam is turned into the vat so as to produce ebullition, which is maintained for seven or eight hours. When the saccharification is completed, the juice is saturated with carbonate of lime, and, after a sufficient rest, the clear liquor is drawn off to be fermented, by the addition of enough water to reduce the temperature to 20° or 24°.

By this process 150 or 200 grammes of dry yeast are sufficient to obtain a very good fermentation, and the result leaves nothing to be desired, since it yields from six to seven litres of pure alcohol to 100 kilogrammes of the root, the taste of which, although sufficiently marked, is far superior to that obtained by the preceding methods.

Finally, as the result of practical observation, it is found that all the processes applied to the distillation of the beet are adapted to the distillation of the roots of the asphodel, particularly that of the hot maceration with the use of sulphuric or some other acid.

Alcohol from Figs.

Generally this spirit is obtained from common dried figs. The fruit is reduced to a pulp by crushing or grinding, and covered with water, and left to ferment. When this is completed the liquid is drawn off, and the marc subjected to the action of a press; the resulting juice is then added to the fermented liquor and the whole distilled.

The operation may be conducted as was done by the author in Algiers. The fruit was covered with water without being crushed, and, after a proper fermentation, which is started spontaneously, was distilled, both the liquid and fruit, by means of a steam jet. By this process the yield is ordinarily from 48 to 52 litres of brandy at 50°, having quite an agreeable odor and taste.

Alcohol from Various Substances (Vegetable and Others).

We have already examined among vegetables, those most usually employed for the production of alcohol or spirits, whether on account of their richness in sugar, the facility of extracting it, or on account of the low price of its production; but it still remains for us to speak of a number of vegetable and other substances which may, under certain circumstances, present some advantages to the manufacturer.

All vegetable substances are susceptible of producing alcohol, because most of them contain sugar, starch, gum, pectine, inuline, and cellulose, and these elements may be easily transformed, by the aid of an acid or some other saccharifying agent, into uncrystallizable sugar, either solid or liquid.

Alcoholizable substances are divided into two classes: the first comprises those which contain sugar or glucose, already formed by nature; the second comprises those which must be subjected to some artificial operation for developing and obtaining the saccharine principle.

Alcoholizable Substances of the First Class.

Carrots, turnips, parsnips, artichokes, pumpkins, the whole family of *squashes* and *melons, cornstalks.* Among fruits: *apricots, cherries, peaches, gooseberries, white currants, raspberries, strawberries, mulberries, elderberries, dates*, &c., may all produce alcohol by some one of the processes already described. It is only necessary to adopt that which has been recommended for analogous substances in the course of this work. *Seeds* and *nuts* of many plants, as well as *roots*, and even *some* leaves, as well as milk of cows and other animals, and honey, have been used to produce alcohol in some of its forms.

Alcoholizable Substances of the Second Class.

Peas, beans, lentils, and various farinaceous seeds, *chestnuts, horsechestnuts* (*buckeye*), *acorns*, &c., are saccharified like grain or starch, either by the assistance of malt or sulphuric acid, and in the same manner as we have described under the proper head.

The root of the *Chinese yam* (*Dioscorea batatas*) will yield seven per cent. of pure alcohol if distilled by the process recommended for the common potato.

Lichens, dahlia, and *madder* are also capable of yielding a notable quantity of acohol. The manufacture of alcohol from the last is, in the *garancine* factories, made a source of considerable profit by utilizing much material that has hitherto been suffered to go to waste, on account of the manufacturers being ignorant of the great source of profit they were daily and hourly throwing away.

Cellulose.—This name is applied to the cellular portion of the wood of vegetables. The parts of plants in which cellulose is found most nearly approaching purity, are, besides those of very young growth, the *pith*, the *down*, the *succulent mass* or *flesh of fruits* and *roots*, that are rapidly developed, and very light woody tissues. It is almost pure in old linen, cotton, the pith of the elder, and in white paper.

Cellulose plays an important part in the growth of all vegetables, because it constitutes the foundation of all the organs. It is no less useful in the economic arts and manufactures, since it constitutes the useful substance of wood and vegetable fibre, as cotton, hemp, &c., and other filamentous substances, which are converted by man into thread, cloth, &c.

In 1819, M. Braconnet discovered the means of converting cellulose into grape sugar or glucose, by the action of sulphuric acid. In less than a quarter of an hour he converted ligneous matter into *dextrine;* then this was very soon transformed into sugar, under the influence of the same acid, diluted with water, and brought to a state of ebullition.

The following is the process as described by him, viz: He takes six parts of hemp or linen cloth well washed and cut into small pieces, on which are poured eight parts of concentrated sulphuric acid, a small quantity at a time. The mass is constantly stirred in order that the cloth may imbibe the acid equally, and at the same time escape as much as possible the risk of heating. The ligneous matter assumes a brown color, and becomes at first a very hard and compact mass; but in less than twenty minutes it is converted into a brown paste, pitch-like and viscous, which is completely soluble in cold water. Enough water to effect its complete solution is then poured on this paste; after which, the acid liquor is saturated with chalk. It is filtered to separate the sulphate of lime; evaporated by a gentle heat, and to separate any traces of lime still remaining in the solution a small quantity of oxalic acid is added. It is filtered again, and the gummy substance is precipitated by the addition of rectified alcohol. The precipitated gum is re-dissolved in water; on evaporating the solution to dryness, a pale yellow translucent substance is obtained, which has a brilliant conchoidal fracture; this is *dextrine.*

If it is desired to transform the ligneous matter into sugar, instead of saturating the gummy paste with lime

as above, it should be boiled for ten hours, care being taken to replenish the water as it evaporates. The dextrine then changes completely into sugar, which may be obtained perfectly pure and white.

From one hundred parts of dry rags, according to M. Braconnet, we can obtain 115 parts of white sugar. This conversion of lignin into gum and sugar is not difficult of explanation, since we know that cellulose is isomeric with dextrine and starch. It is none the less truly marvellous when we thus see that a simple derangement in the elementary principles of a substance is sufficient to effect an entire change in its properties. All ligneous substances, as different kinds of wood, bark, straw, &c., like rags, are capable of producing sugar. It was not altogether a witticism when a learned professor exclaimed, that in the present state of the science, a block of wood becomes a loaf of sugar in the hands of the chemist.

Alcohol from wood was the subject of a communication to the Academy of Sciences at its session October 23, 1854. M. Pelouze presented a small sample on the part of one of his pupils, M. Arnould. He describes the process used by him as follows, viz:—

"Under existing circumstances, when the manufacture of alcohol has been so largely developed that it has turned many primary substances, particularly the cereals, from their legitimate and most useful application, I have thought it a matter of some interest to present to the Academy some researches into a new method of producing alcohol, although these researches are not yet complete.

Encouraged by the experiments of M. Braconnet, published thirty-five years ago, and by the more recent publications of M. Payen, I have undertaken to produce substances analogous to starch, sugar, and alcohol, from vegetable fibre, and especially from wood.

My first efforts have completely answered my expectations. I have succeeded with certain fibres in rendering soluble 97 per cent. of the substance used, and for

certain varieties of woods I have succeeded in rendering soluble from 75 to 80 per cent. of the wood employed, and have then converted the sugar into alcohol.

The following is a brief summary of the process of preparing alcohol from white wood :—

The wood, in the form of coarse sawdust, is dried at 100° so as to drive off the water it contains, which is often more than half its weight. When cold and in a suitable vessel, concentrated sulphuric acid is poured on it with great care, and in small quantities at a time; the acid is poured on very slowly to prevent the matter from being heated. The acid is mixed with the wood as it is poured in, then the mixture is allowed to rest for twelve hours; after which it is stirred carefully until the mass, which is at first almost dry, becomes fluid enough to pour. The liquid, diluted with water, is then heated to ebullition; the acid is neutralized by chalk, and the liquor, after filtration, is subjected to fermentation, and then the alcohol is distilled off by the ordinary processes.

In this experiment the quantity of sulphuric acid employed might have been equal to, while it might not have been less than 110 per cent. of the weight of the dry wood used.

From researches in progress, I am led to believe that the quantity of acid may be considerably reduced; but even now with the proportions indicated above, alcohol may be economically manufactured from materials as cheap as wood, sulphuric acid, and chalk.

I hope that the Academy will excuse my having presented a work not yet completed, on account of its importance as a matter of public utility. In fact, the nation has at its disposal a new and almost inexhaustible source of food, since from wood, *dextrine*, *sugar*, and *alcohol* can be produced so economically. Governments will see that famines, so painful to all, become more and more rare, if not impossible, since wood will contribute doubly to the general supply of food at first directly, and then by yielding products which have been drawn

mainly from the cereals, which constitute the principal article of food to all peoples. This new application of wood will restore to a product so abundant, and the preservation of which, in so many respects, is so important, a part of its value, at a time when it is almost driven from use by the applications of iron and coal."

Doubtless all these speculations of M. Arnould are very beautiful, but are they not illusions so common with inventors! It is not everything to produce alcohol, it must be produced at such a price as to yield a profit from which the distiller should be remunerated for his labor; and although fully recognizing the merit of those men of science who consecrate their lives to opening up new processes, we practical distillers hold ourselves in reserve. Let us leave to philosophers the care of making scientific discoveries; let us apply ourselves to introducing them into practice only when we are fully satisfied of their practicability, or where experience has assured us of success.

Madder.—We copy from the interesting work of M. Paul d'Aspremont the following details, which include some notice of the factory of Messrs. Julian fils et cie, at Sorgues (Vaucluse).

This factory turns out every day 1200 kilogrammes of *flowers of madder*, and 2500 kilogrammes of garancine. M. Julian, the father, discovered the flowers of madder in 1852, and he was one of the first, in 1847, to distil the washings of madder for the purpose of obtaining alcohol. At present, when this factory is in full operation, it produces as much as 800 litres of spirit at 87° in one day, which indicates a consumption of 8000 or 9000 kilogrammes of the powdered root. The wash (or waste waters) do not yield more than two per cent. 1000 kilogrammes of powdered madder yield 70 or 75 litres of alcohol at 85°.

The preparation of the roots to render them fit for the use of the dyer is not very complicated. As the farmers or their brokers bring in their products, they are spread out in extensive sheds. As all purchases are for cash, it

follows that the factories should be possessed of a large capital. It is not possible for me to ascertain the exact figures; but I infer from the amount of the entire product, which is not far from thirty-five or forty millions of kilogrammes for Vaucluse and the neighborhood, that during the course of the season, the manufacturers disburse twelve or thirteen millions of francs. I do not speak of the large quantities which come from Naples and the Levant, and which are imported into Vaucluse to be manufactured. Without exaggeration, we may well estimate the floating capital necessary to carry on the madder factories of this department at fifteen or sixteen millions.

The first operation to which the root is subjected is that of drying. It is placed in a drying-room heated to about 50°, where it remains 48 hours. M. Julian uses, every day, 130 bales of 85 kilogrammes each.

The second operation comprises scraping, winnowing, and grinding. The roots are first freed from the earth which adheres to them; they are then passed through the winnowing machine, and are thrown under vertical grinding stones, which reduce the roots to powder. This product bears the name of *powder of madder* or *ground madder*. It is used to dye red on cottons, and other common materials. The powder contains all the mucilaginous substances and saccharine elements of the root, which tends to enfeeble its tinctorial power. It, therefore, yields much less coloring matter than the flowers of madder, which is much more concentrated. The powder sells for 80 francs for the *common* and 92 francs for the *palus* per 100 kilogrammes.

The flowers of madder was discovered in 1852, by M. Julian (the father). The product is used to dye in light tints. The following method is used for preparing it: The ground madder is placed in a box, and six times its volume of water is poured on it. It is then filtered through a woollen cloth, pressed, dried, ground to powder, and the *flower* packed in barrels. In this state it is put on the market. The price is from 160 to 200 francs for 100 kilogrammes.

The flowers of madder is debarrassed by the washing and pressure of all the mucilaginous substances which the roots contain; the proportion varies according to the nature of the soil on which it has grown. Calcareous soils produce purer madders of more lively color. These are better adapted for making the flower.

The waters which have been used for washing the powder, as well as that from the press, are collected together in vats, where they are fermented by the ordinary processes.* The first runnings which were obtained by this method, in 1847, sold for eighteen francs per hectolitre, at 80°. This alcohol had a horrible empyreumatic taste; but since that time a Pole, M. Pongoski, has discovered a means of rectifying madder spirit so that it sells at the same price as beet spirit, and is used for the same purposes.

Garancine is the third product obtained from madder root. First, the powder is washed and pressed, as if intended to produce the flower. The washings are used for making alcohol. After this operation the powder is placed in vats and covered with water, acidulated with from 25 to 40 per cent. of sulphuric or muriatic acid. It is boiled for an hour and a half. The liquor drawn off, is not distilled, unless alcohol is at a very high price. The powder is placed in other vats, where it is washed with cold water. The acid which still remains is neutralized by soda; the second washing lasts twenty-four hours. It is then left to drain, and when dried and ground, the garancine is packed in casks. This preparation is used in printing calicoes.

The discovery made, in 1857, by M. Pongoski has given a great value to madder spirit. M. Santel, of Sorgues, tested the process, which is as simple as it is ingenious. The process consists in passing a jet of

* In the establishment of Arthur & Hinshaw, at Edinburgh, the fermentation is spontaneous or artificial. Leaven does not appear to hasten or modify the operation.—*Translator.*

alcoholic vapor into a distilling column charged with charcoal in coarse powder. This charcoal absorbs the empyreumatic oils contained in the spirit, and alcohol is thus obtained of good flavor, or rather without any sort of flavor.

The coal used by M. Sautel is prepared from willow, poplar, or birch. The wood is inclosed in retorts and distilled. It requires 600 or 700 kilogrammes of green wood to make 100 kilogrammes of charcoal. The cost of production is 20 francs. With 100 kilogrammes 5 hectolitres of alcohol are rectified. The coal loses 10 per cent. of its value every time it is used. It may be revived by reheating it in the retort. The cost is almost nothing.

It is obvious from these figures that the process of Pongoski is but little dearer than the common process, and that it may be applied to the rectification of beet spirit. The attempt has already been made at Lille and with success. M. Pongoski also applied his discovery to the rectification of pyroligneous acid; he thus avoided many successive distillations and obtained an article of good flavor at the first jet.

His distilling apparatus is like any other; only he adds a second column, in which he effects the absorption of the essential oils. It is proper to state that a little more pressure is necessary. The apparatus of M. Sautel was constructed at Sorgues. It yields 150 litres, at 95°, per hour. This is a little too strong, and is subject to some loss in transportation; but it may be reduced to 90° by the addition of water.

M. Sautel made alcohol of 100° by a process peculiar to himself, and sold it for three francs the litre. By the use of charcoal, he made ether of good flavor at the first operation. His factory is in operation only eight or nine months of the year. The unpleasantness between the states of North America has very much reduced the demand for flowers of madder.

On the day of my visit, M. Santel paid 48 francs for backings, at 86°, without the barrel. In Paris, at that

time, beet spirit was worth 68 francs. The difference between backings (*flegmes*) and rectified trois-six is always from 20 to 22 francs. The rectification which costs eight or ten francs is always reckoned at fifteen or sixteen francs by the seller. The pipe of six hectolitres costs twenty-four francs; it is reckoned at the rate of six francs to the hectolitre. The sales are made at 90°, as is done with the alcohol of the beet. Backings, as well as rectified trois-six, are stored in stone cisterns.

The production of the department of Vaucluse is, according to M. Sautel, from 1800 to 2000 pipes per annum. This is small when compared with the alcohol formerly produced from the wines of the South of France, which is estimated at 120,000 pipes.

At present, not more than 25,000 or 30,000 pipes are made from wine. In the north, the amount produced is not exactly known, because the beet is sometimes converted into alcohol, and sometimes into sugar. Last year the north produced 190,000,000 kilogrammes of sugar, and 130,000 pipes of alcohol. The 2000 pipes which are produced from madder do not then make much impression on the market.

Madder spirit rectified, according to the process of Pongoski, is sold as alcohol of good flavor, and for the same purposes. At the rate of 68 francs, the 12,000 hectolitres so produced, are worth more than 800, 000 francs, which, before the discovery of M. Julian, was suffered every year to flow into the sea. Our gratitude is therefore due to M. Julian for his happy idea, and the more so, since the manufacturers of madder reduce the price of their product by the value of the alcohol obtained from the waste washings. It is in this way that each new discovery tends to lower prices, and improve the condition of the consumer.

General Observations on the Different Kinds of Alcohol.

From what has been said about the different varieties of alcohol, we draw the following conclusions:—

1. That the processes used for distillation are always the same.

2. That they only differ in the methods adopted for preparing the materials for fermentation.

3. That all substances, whether vegetable or not, which contain sugar, glucose, or any principle that may be converted into either, are susceptible of passing through the alcoholic fermentation.

4. That, to obtain this result, it is sufficient to set free the saccharine matter by rasping, pressure, maceration, and saccharification.

5. That this saccharine matter must be diluted, when necessary, with a sufficient quantity of water, to cause the liquid to mark five or six degrees on the areometer of Baumé.

6. And that, in conclusion, alcohol should be extracted only from those substances which, by their moderate price, or the facility of their production, will enable it to compete with spirits of wine, or the trois-six of Montpellier, either in price or quality.

CHAPTER VII.

RECTIFICATION.

The object of rectification is to increase the spirituosity or standard of alcoholic liquids, which have already been distilled, and at the same time remove those substances which give them a bad flavor. This operation is based on the difference of volatility between these substances and alcohol.

The spirits obtained by the various processes which we have described do not always possess that purity which is required in trade, although they may be of the proper alcoholic standard; it is important, therefore, to rectify them in order to remove the peculiar and disagreeable flavor derived from the various foreign sub-

stances accompanying them. It is frequently necessary to make a second rectification to have the purification perfect.

Before entering into the details of rectification, and in order to have a better comprehension of this operation, it is proper to be acquainted with the substances which mar the purity of the alcohol, and the different causes that exercise an influence on its quality. Among these, the essential oils and acids occupy the first rank; then comes the action of heat. Indeed, the products of rectification are of different natures. The first, that is, those which flow at first, contain highly volatile, ethereal principles, in greater or less quantities, according to the perfection of the fermentation; they have a suffocating and disagreeable odor, due to the presence of a certain quantity of *aldehyde*, and usually have a light yellow color. The second are generally purer and without color, and are endowed with a sweeter and more pleasant flavor; it is from such products that the well-flavored (*bon goût*) trois-six is obtained. The third are much less pure; they contain an appreciable quantity of *amylic alcohol;* that is to say, alcohol mixed with a great quantity of essential oil; their odor is strong and disagreeable. Finally, the last products consist only of essential oils, almost pure and of a repulsive odor.

Essential Oils.—We have already said that alcohol is the result of the decomposition of the saccharine principle, which takes place during the vinous or alcoholic fermentation. We should add, that from whatever substance obtained, it is, chemically speaking, identically the same. This truth is incontrovertible; but it is impossible to doubt that if all alcohols have the same chemical properties, their tastes and odors are as various as the substances from which they are obtained. It may be remarked that the various raw materials are distinguished by the peculiar aroma and distinct shades of flavor in the alcohols which they produce. It is by this means that we recognize at once not only the alcohol from cherries, beets, or molasses, together with that from the grape; but we find a decided difference between the brandies

of Languedoc, Cognac, and Montpellier, &c., although all these brandies are produced from the fermented juice of the grape.

Now, to understand the solution of the problem which we have in hand, it will be sufficient to recall the fact that plants, roots, flowers, fruits, &c., owe their perfumes to the presence of an essential oil, soluble for the most part in alcohol, and that this essential oil varies in its perfume not only for each particular substance, but even in the same plant according to soil and season.

The essential oils, so various in their perfume, affect the organs of taste as well as those of smell; the taste of the rose is readily distinguished from that of the orange flower. Therefore, since these oils exert such a decided action on the senses, and as they differ in each substance, it is evident that to obtain a spirit free from peculiar flavor, it is necessary to deprive it of the essential oil which it may hold in solution. We shall describe more particularly the peculiar characters of the essential oils, when we come to treat of aromatic waters and spirits. They are volatilized at a heat not exceeding 100 degrees, and often much below, although they do not begin to boil until heated to 130 or 150 degrees; they are also very soluble in alcohol, and but little so in water.

After what has been said, if we recollect the principles of distillation, it will be easy to separate the alcohol from this essential oil, because it requires a higher temperature to volatilize it than to drive off the alcohol in the form of vapor; and it is ascertained that the more nearly alcohol approaches a state of purity, the more readily it is separated from the essential oil, because a heat of 78 degrees is sufficient for the vaporization of the former. This principle established, we can easily preserve in an alcohol the perfume which is agreeable to the consumers, or extract that which is disagreeable.

If we desire to test the presence of essential oils in non-rectified brandies, it will be sufficient to take Cognac brandy, for example, and rectify it with the necessary care; if this spirit is diluted with water, it will be found

that it no longer has the flavor of Cognac; the essential oils have not then been volatilized, and the agreeable bouquet which constituted the real merit of this brandy has disappeared.

Potato spirit may afford another example. Carefully rectified, it yields a considerable quantity of essential oil, which may be burned in a lamp, and a single drop of which is sufficient to communicate to many litres of good brandy that nauseous flavor and harsh taste so recognizable in ill rectified spirits made from amylaceous substances. It is the same with brandy made from the marc of grape (pomace).

The most conclusive example that we can give of the presence of essential oils in non-rectified brandy, and that the quantity which is vaporized is in proportion to the temperature necessary to the vaporization of the alcohol, according as the latter approaches a state of purity, is the nebulous tint of the feints (low wines); for the weaker the alcohol the more nearly must the temperature necessary to vaporize it approach that of boiling water; then the essential oil, finding a temperature better adapted to its vaporization, will pass over into the receiver in greater quantity.

We have said that essential oil is very soluble in alcohol, and but little so in water; it follows, then, that the weaker the alcohol the less essential oil will it dissolve; this occasions the nebulous appearance of the feints; for the great quantity of essential oils and the feeble strength of the alcohol they contain, both concur in leaving the essential oil in a state of suspension. If a proof of this fact is desired, it is only necessary to add a few drops of any essential oil to a rectified alcohol; the oil dissolves at once; if then a large quantity of water is added to this aromatized alcohol, its solvent power being greatly diminished, the mixture will become clouded; this is what happens when cologne, essence of lemon, or fine absinthe is mixed with water.

It has been attempted by an infinite number of methods to remove or destroy the bad flavor which the essential oils give to alcohol, and a number of chemical agents

have been employed for attaining this result; but up to the present time none of these agents have fulfilled the object in view, and most of them communicate to alcohol properties peculiar to themselves which are more injurious than useful. Frequently they only mask for a longer or shorter time the odor which it is desired to remove, and which will reappear with more force than ever.

The alkalies, lime, soda, and potassa, act only to a slight degree on the essential oils, for to convert them into soap it is requisite that they should be resinified by the action of oxygen, which cannot take place in the condition in which they are found with alcohol. In the rectification of alcohol, the use of muriates, silicates, borax, alumina, tannin, charcoal, plaster, magnesia, and clay, produces imperfect results.

The action of some acids upon the essential oils is, it is true, very energetic, but it is necessary that these acids should be concentrated; for example, sulphuric acid resinifies and carbonizes them; hydrochloric acid dissolves them; nitric acid also dissolves them and converts them into a substance very nearly approaching the resinous state, if it is diluted with water in proper proportions; if it is concentrated it causes them to burst into flame. It is necessary, then, that on the one hand the acid should be concentrated, and on the other, the essential oil should be brought in contact with it in a state of purity. But what can be expected of these reagents when they are dissolved in a great quantity of water and the essential oil itself is in a state of minute division?

Chlorine and the chlorides mask the odor of essential oils for a time, but do not remove it, and the liquids which have been treated by them, when exposed for some time to the air, or when kept in store casks not only resume their original odor, but it is increased by the emanations of chlorine, which render them unfit for the manufacture of brandy and liquors.

It is proper to conclude, then, from what has just been said, that rectification conducted with care and intelli-

gence is the only means of destroying the odor of alcohols in a satisfactory manner.

Acids.—The essential oils, by the agreeable or repulsive odor which they diffuse, are not alone in contributing to the good or bad quality of alcohol. The presence of certain acids may also play an important part, although a secondary one, in giving a sharp and biting taste which will affect the consumer unpleasantly. This fact was established conclusively by Parmentier. The troops had complained for a long time that detestable brandy was issued to them; no other could be had, and the soldiers murmured. Parmentier was consulted; he examined the brandy and found the taste horrible; in seeking the cause, which could not escape his sagacity, he recognized the presence of an acid. He at once saturated it with ammonia, and the brandy became palatable.

All fermented liquids contain acids of different kinds and in variable proportions, according as the acids are the result of the fermentation, or are the product of the fermentable materials. Thus, all grape wines will furnish tartaric acid, and sometimes carbonic and acetic acids; cider, perry, the wines of cherries and gooseberries, yield malic acid; the wines of molasses, beets, grains, potatoes, etc., generally yield acetic acid, although these substances do not contain it; this acid is formed spontaneously during the vinous fermentation, and it may also be the result of a fermentation more or less acidified. These last wines may also contain lactic acid as the product of a vicious fermentation.

Like the essential oils, the acids require for their vaporization a higher temperature than is necessary for water; the result is, that whenever it is desirable to preserve the aroma of a spirit, the acids are also retained, and vice versa.

The presence of acids in liquids which it is desired to subject to rectification, and particularly acetic acid, facilitates their combination with alcohol, and gives rise to different ethereal principles endowed with very great volatility. These principles, as soon as the liquids

are heated, pass off, at first, in a gaseous state, next they mingle with the first products and bring along with them a certain quantity of essential oil, especially in potato and beet spirit. We see then that acetic acid not only destroys a portion of the alcohol during the vinous fermentation, but that also, by its presence in the spirits, it proves very injurious to the quantity of the mass unless it is saturated by an alkali, especially lime.

Action of Heat.—The excessive action of heat on liquids which are subjected to distillation by the open fire has been known for a long time, and its influence on the flavor of the spirits has been well understood by distillers. Indeed, these liquids contain mucilaginous substances which attach themselves to the bottom or sides of the boiler which receive the heat directly and are decomposed, thus producing acetic acid and an acrid empyreumatic oil; so the peculiar taste of the still is generally known by the name of *empyreuma;* independently of this taste the heat when pushed actively causes the essential oils to pass over. We may well conceive that rectification should be employed to deprive the alcohol of the products of this decomposition, for the prevention of which the process of distilling by the water bath and by steam has been adopted.

Now that we know the causes which produce the offensive flavor, it becomes our duty to indicate the means, by the aid of which, we may diminish or remove it. These means resolve themselves into the *saturation of the acids*, and *separating the product* (*fractionnement des produits*).

The saturation of the acids is effected by caustic lime, in the proportion of fifty grammes to the hectolitre of spirits to be rectified, having first mixed it with a sufficient quantity of water to make it of the consistency of cream. This proportion of lime is not absolute. It may be increased or diminished as the liquid is more or less acid; nevertheless this is about the quantity that has succeeded best in our hands in the rectification of alcohol from beets.

Soda and potash may be employed for the same pur-

pose instead of lime, but the latter is much cheaper, and answers exactly the same purpose.

When the liquid has been properly neutralized, as shown by the use of litmus paper, the rectification is proceeded with, without drawing off the clear liquor, as the lime does not interfere with the distillation.

The separation of products resulting from the rectification, is the first condition of the quality of the spirits. This operation requires great skill in tasting, and much care, for the products which pass over at the beginning, and at the end of the rectification, are strongly sapid and odorous, while those which pass over during the middle of the operation, are more or less free from taste and smell. M. Ch. Derosne was the first to point out this important fact, and for a long time it was considered a great secret by the rectifiers.

It would be very difficult to indicate the moment when the liquid should be separated, that is to say, when the pure product should be collected; this is regulated by the nature of the spirits rectified; some may be pure twenty or thirty minutes after they have attained the desired degree, and some others run pure only an hour or hour and a half, sometimes even more, after they have attained the required degree. It is necessary to taste the product frequently, taking care to dilute it with water, or to pour a few drops into the hands, and after striking the hands together quickly to see if, by the odor, the alcohol is acceptable or not; these two means may be applied simultaneously. The separation is, as we have seen, a delicate operation, requiring a certain amount of skill.

Management and Progress of Rectification.

Rectification by means of the apparatus described at page 75, Figs. 1 and 2, Pl. V., is conducted as follows:—

The still *A* is filled four-fifths full with spirit, of less than 50°. The condenser *E* and the cooler *G* are filled with water; then the cocks *I* and *V* are examined to see that they are closed. Everything being thus arranged,

steam is turned on carefully, so as to heat the liquid gradually, in order that the operation may be slow, but continuous. The alcoholic vapor soon rises above the first plates *a* of the first section of the column *B B B*, and passes entirely through the latter, and by way of the cap *C* and the pipe *D* into the condenser *E*. Immediately on reaching the *lentils*, $d\, d^1$, this vapor is condensed, and returned upon the upper plates of the column *B* through the return pipes f and f^1 and g and g^1, where it is volatilized and constantly recharged with alcohol, to be again recondensed until the water in the condenser is sufficiently heated to permit the lighter alcoholic vapor to pass into the convolutions of the horizontal coil *c c c* without being reduced to the liquid form.

As soon as the water in the condenser *E* is sufficiently warm, the vapor passes by the pipe *F* into the cooler *G*, where it is converted into a liquid as it comes over. This is the point at which the closest attention should be paid to the heating, because it may happen that the vapor, by heating too abundantly, may not be entirely condensed, and may pass off in a gaseous state, or may flow off as hot liquid.

The first product of the distillation always contains the ethereal principles which are generally the least abundant; that which follows is more or less pure; then follows, in due course, well-flavored alcohol; and last, the product containing the essential oils, which, in some substances, are quite abundant. Each product should be separated and set aside, so that those which are most contaminated with impurities shall not be mixed with those which are least so. It must be remarked that well-flavored alcohol can be obtained only when the strength is kept between 92° and 96°.

Generally, the liquid must be heated for two or three hours before the first flow of the rectification, because the distillation is effected within the apparatus, and by means of the return pipes which return the heavier portions to the twenty plates of the column to be purified and recharged anew. The importance of this return of the spirits has been sufficiently demonstrated in speaking

of the apparatus of Derosne, and we may be excused from repeating it.

Care should be taken during the progress of the rectification to keep up a constant supply of fresh water in the cooler, so that the liquor may always flow quite cold, without, however, reducing the temperature so low as to interrupt the operation, which will certainly happen if the cap of the cooler is not kept moderately warm; because, in that case, the cold water, by reason of its weight being greater than the warm water, will immediately pass through the latter into the condenser, and will then rapidly condense the alcoholic vapors, which, instead of passing into the cooler, will return to the column by the return pipes.

The operation is complete when the liquor which flows through the proof vessel marks not more than 3° or 4°; but it is better to suspend the operation as soon as the heavy phlegm (backings or feints) indicates 10°, because the product which then passes over is highly charged with essential oils, and is not worth the time spent in saving it. Moreover, this last product, by reason of its nature, adheres strongly to the surface of the plates and the coils, and renders the cleaning much more difficult.

The apparatus should be cleansed as soon as the operation is finished, so as to take advantage of the hot water in the condenser. For this purpose the stopcock *Q* is opened to draw off the water contained in the boiler *A*; then the cock *J* of the pipe *K* is opened to empty the hot water from the condenser on to the plates, to remove the essential oils which remain in them. The condenser and boiler being empty, the cocks *J* and *Q* are closed, and the plate *U* is removed; then by means of a pipe, the water in the cooler *G* is entirely emptied into the boiler *A*, so that the steam coil may be covered to the depth of 18 or 20 centimeters. When this has been done, the screw plate *U* is returned to its place and secured, and a strong heat applied. Ebullition soon begins, and the steam which escapes from the boiler in great abundance, carries with it all the essential oils adhering to the different parts of the apparatus. After

fifteen or twenty minutes, when it is perceived that the steam no longer has any taste, the heat is cut off, and the apparatus left to cool gradually, in order to avoid cracking the soldered joints by cooling too quickly.

The application of steam as a means of heating in rectification is without contradiction the best of all, but if the operation is conducted over the open fire, care must be taken not to allow the naked bottom of the still to be exposed to the fire when the waste liquor is drawn off from the boiler; it must never be entirely emptied, but must remain covered by at least ten centimeters of liquid.

The bad-flavored spirits resulting from rectification may be rectified anew by adding to them nearly an equal quantity of water, so that they may be at 40 or 50 degrees Cent.; this addition of water is indispensable to set the essential oils free, and it is for this reason that we said above that alcohol should never be rectified at a higher degree than 50°.

This method may at first glance appear to be contrary to the principles we have laid down, in saying that the more nearly alcohol approaches a state of purity the more readily it is deprived of its essential oils and acids, in view of the low temperature at which it is vaporized. But it must also be observed that alcohol, having a strong affinity for essential oils, when it is concentrated, dissolves them in large proportions, and forms with them an intimate union.

It is in this manner that the aromatic spirits and essences, of which we shall speak hereafter, which contain a large quantity of different essential oils, pass over by distillation entirely without change of character, while, if they be diluted with two or three times their volume of water before being rectified, the alcohol, which has greater affinity for the water than it has for the essential oils, will separate from the latter to unite with the water, and the essential oils will be set free. The liquid, then, which results from this rectification will be almost entirely free from the essential oils which will be found in the boiler of the rectifying apparatus, collected together on the surface of the fluid contained therein.

The last products of the rectification, that is to say, the feints or backings should, on account of the large quantity of essential oil they contain, be made the object of a special rectification. The alcohol obtained from them, it matters not what care has been taken with the operation, still retains a very unpleasant odor, of which it can only be deprived by many rectifications.

We have often been asked what is the proportion of well-flavored alcohol that can be obtained from a successful rectification. This question is very difficult to be answered. The proportion is very variable; it is dependent on the nature of the liquor to be rectified, on the method of extracting the saccharine matter, and on the manner of distilling. The quantity of well-flavored alcohol obtained will be in inverse proportion to the quantity of essential oils contained in the liquor.

The loss by rectification is usually estimated at five per cent. of pure alcohol.

It must be observed that the capacity of the rectifying apparatus has a very great influence on the production of trois-six of good flavor (*bon goût*). Small apparatuses will not furnish the same quantity in proportion; they are always more difficult to manage, and the stream of flow has not the regularity which characterizes the large apparatus. It is certain that the more extensive the apparatus the better will be the quality and the larger the quantity of the trois-six obtained.

Purification of (Backings) Phlegm (Spirits of bad taste, from Beets, Potatoes, Grain, &c.). By M. Ortlin.

The first process is founded on the oxidation of the substances infecting the alcohol, by means of hypochlorous acid, which renders the offending substance highly volatile, and facilitates its separation from the alcohol by distillation.

For ten hectolitres of alcohol, 1st, dissolve one kilogramme of chlorate of potash in a sufficient quantity of boiling water, and add this solution to the alcohol, stirring it thoroughly; 2d, three and a half kilogrammes of commercial hydrochloric acid are added and well

mixed. After digesting 24 hours, during which it is occasionally stirred, it is distilled in the usual way; managing the fire so that the alcoholic vapors shall be at a higher temperature than 45° Cent., when they reach the cooler. The product is purified alcohol. The dose varies with the amount of impurities contained in the alcohol.

In the second process, for ten hectolitres of badly flavored alcohol, dissolve 1.6 kilogramme of bichromate of potash in five litres of hot water; this solution is mixed with the alcohol, which has been previously diluted with four hectolitres of water; after being well stirred, 1.9 kilogramme of sulphuric acid at 66°, diluted with 1.3 kilogramme of water, is added. They are mixed by prolonged stirring. After being digested for several days, and the liquid from being yellow has changed to green, five hectolitres of water are added, and it is distilled in some good apparatus. The separated product of this rectification is purified alcohol. The proportion will be diminished on account of the removal of the infecting substances.

The bichromate of potash, under the influence of the sulphuric acid, parts with one-half of its oxygen, and produces the sesquioxide of chromium; the free and nascent oxygen unites with the amylic alcohol, producing valerianic acid, which is much less volatile than alcohol, and does not pass over during the rectification.

CHAPTER VIII.

DISTILLATION OF BRANDIES.

Spirit, the density of which varies between 40° and 60°, is generally called brandy (eau de vie); but this name is most usually applied to the product of the distillation of wine, although we do say (in France) grain brandy, cider brandy, &c. Brandy is, therefore, only a

mixture of alcohol and water, obtained by distilling fermented liquids, and which contains in addition certain foreign substances that are peculiar to these liquids, such as acetic, and hydrocyanic acids, a volatile oil, and especially a coloring matter which it extracts from the casks in which it is stored.

The distillation of brandies, unlike that of alcohol (or spirits heretofore described), is so conducted as to preserve in the spirits the aroma which distinguishes them, and which constitutes their peculiar merit. This operation should be effected on the principles hitherto set forth, and by means of the apparatus of Derosne or Egrot, or by a simple apparatus, as is done in many places; but in the last case the product must be redistilled, in order that it may have the proper degree of alcoholic strength.

Brandies from Wine.

The quality of brandies is dependent on many circumstances, especially the maturity of the grapes, the perfection of the expressed juice; the care given to managing the vinification; on the conduct of the distillation of the wine, which should be observed carefully to prevent the extractive matter from being burnt during the operation; on the intimate union of the volatile principles with the alcohol during the distillation; on the aroma of the wine which has been more or less retained in the product of distillation, &c. &c.

The quality of brandies depends, too, on the age of the wines; on their variety and state of preservation; for all wines are not equally suited to the manufacture of good brandies. Old wines yield a much better article than the new. The product of sweet wines is excellent. Spoiled (turned) wines produce brandy of very inferior quality. White wines are preferable to red wines for distillation, because, as a general rule, they yield better brandy than the latter. This results from their not having been vatted on the skins and stalks of the grape. They contain a much smaller proportion of the essen-

tial oils which are found in the husk of the seed, and which dissolve in the must under the influence of the alcohol generated during the fermentation.

It is remarked that, as a general rule, the wines which produce the best brandies; those of Charentes, for example, are more or less inferior as table wines, and are quite difficult of preservation. They are called *Vins de Chaudière.*

Wines that have the taste of the soil communicate it to the brandy extracted from them. This is the reason that the wines of Seyssel and Dauphiné yield a brandy having the odor and flavor of the Florentine iris, while those of Saint Peray yield a brandy with the odor of violets, and we observe the taste of brimstone in the wines of Côte-Rôtie, that of slate in the wines of Moselle, that of amber in the wines of Holstein, &c.

When brandy has just been made it is colorless. If it is immediately bottled, as is done with Kirchenwasser, it will never acquire any color; but as it is usual to preserve it in oak hogsheads, it attacks and dissolves a certain quantity of coloring and extractive matter from the wood, and then acquires a reddish-yellow tint.

Brandy should be very clear, very white when new; a light amber tint if three or four years old, and very yellow if it is very old. It ought to be agreeable to the taste, or at least should be free from empyreumatic and foreign flavors.

Brandies are greatly improved by age. They lose a little of their alcohol when kept in barrels; but their elements combine more intimately; they lose the slight taste of the still, which the most carefully prepared brandies retain for some time, and they become at last more oily and more potable.

Brandies are easily preserved, as temperature exercises no influence on their quality. To prevent evaporation, they should be carefully sealed; for it costs a good deal to keep brandies, especially when they are new.

The brandies most esteemed are those of the department of Charente; and the cantons which yield the best

are *Champagne*, canton of Blanzac, 16 kilometers from Angoulême; the country of Cognac; that of Jarnac on the right bank of Charente, 12 kilometers from Cognac; Rouillac, 22 kilometers northwest of Angoulême, and 20 kilometers northeast of Cognac; Aigre, 21 kilometers from Ruffec. All the brandies of this department, and those of some cantons of Charente-Inferieure are known to the trade as *Cognacs*, and participate more or less in the qualities of those we have cited. Generally all of these brandies are noted for a purity of flavor and delicacy of perfume which is attempted to be imitated in vain.

Champagne brandies are divided into two sorts, or two different qualities; the first is known as *fine Champagne*, and the second as *country brandy* (*des bois*); the latter not so highly prized.

Next to the Cognacs, the brandies of *Saint-Jean-d'Angely* are most highly esteemed. Their softness and purity of taste often cause them to be confounded with the former.

The brandies of Charente-Inferieure are known under the name of *Cognacs of Saintonge* and of *Aunis*. They have much less reputation and quality than those of Charente, because of a certain taste of the soil which is peculiar to them, and because of their wanting in delicacy. The brandies of *Surgêres*, *Mauzé*, and *Rochelle* are different varieties from this department. The first are most esteemed.

The brandies of the two *Charentes*, as made, weigh usually from 60° to 68°, but they are delivered to the trade only at from 58° to 60°; the medium, aged and old brandies are put on the market at from 49° to 59° (Centesimal). All of them are put up in very neat and well-hooped barrels. The *casks* (*barriques*) contain from 300 to 350 litres; the vessels of less capacity are called *quarters*.

The brandies of Marmande are manufactured in the department of Lot-et-Garonne. Although quite fine, they have an earthy taste, which reduces them to the rank of common brandies.

Among the common brandies, those of Armagnac hold the first place; they are distinguished by a taste of the soil, which is quite pleasant and improves very much by age. They are manufactured in the departments of Gers, of Upper and Lower Pyrenees, as well as in the Eastern Pyrenees; they are sent to market gauged at 50°, in tolerably well-constructed tierces of very thick wood, which contain 400 litres or more.

The brandies of Montpellier are the most common and least sought after. They have a very feeble bouquet, and but little delicacy. They are put on the market in casks; their alcoholic strength varies from 50 to 60 degrees.

There are few vine-growing countries that do not produce brandy. The departments which produce the most, after those already named, are, Ardèche, Aude, Bouches-du-Rhone, Dordogne, Gard, Haute-Garonne, Herault, Landes, Loir-et-Cher, Loire-Inférieure, &c.

The name of *proof* is given to the different degrees of potable brandies; thus, the *preuve de Hollande** corresponds to 19 degrees Cartier, or to 50° centesimal. A liquor of this degree, when agitated in a glass vial, produces small bubbles, which will remain for a while; this happens neither for a higher nor a lower degree of strength.

The brandy trade is subject to great vicissitudes. on which the price of the commodity depends. These vicissitudes induce very uncertain speculations, which may result in heavy profit or as serious loss to the operator. It is also subject to the chances caused by a good or bad wine crop. These circumstances will soon be learned by a tradesman who follows his business with any skill. His prudence will teach him to lay in his stock during those years when brandies are at a moderate price; but as brandy in store is the occasion of much expense, it is necessary to know how to calculate this

* Brandy is now regarded of good quality and proper standard when, after being violently shaken in a vial not quite full, it makes a *bead*, that is to say, forms a circle of small bubbles which arrange themselves against the inner wall of the vessel on the surface of the liquid. This is what is called *preuve de Hollande*, or *Dutch Standard.*

expense, together with the profit which an advantageous sale will produce. In this calculation he should take into consideration the value he would receive, if his money had been put at interest. It is rare that five years in succession pass without there being a scarcity of brandy which causes the prices to advance considerably, thus giving the dealer who has a stock on hand a profit far above his expenses and the interest on his money.

(Marc Brandy) Brandy from the Grape Pomace (Marc de raisin).

All vine-growing countries produce *marc* brandy. Languedoc, especially, furnishes it in great quantity, converted into spirit of wine, or *trois-six*, which is diluted or reduced to make the marc brandy. Burgundy, Champagne, and Lorraine distil a good deal, and the production of these countries is always insufficient for their own consumption.

The marc of the grape, notwithstanding the care that may be taken in pressing it, always contains a certain quantity of wine, and consequently alcohol. In the south there remains in the marc a certain portion of sugar that has escaped the vinous fermentation, which is always incomplete, and of which the most energetic pressure cannot deprive it. This sugar, being decomposed, will still further increase the volume of spirits.

Usually the process for obtaining marc brandy is very objectionable; the following is the method pursued in vine-growing countries:—

The marc, on leaving the press, is borne to a deep pit dug in the earth; sometimes plastered with clay, in which it is packed and pressed as it is brought. When the pit is full, it is covered with straw, vine leaves, and twigs, over which is thrown a thick bed of earth to prevent contact with the air. The whole is left to ferment for about six weeks.

When it is thought that the fermentation is completed, they commence to distil the marc. For this purpose the boiler of a simple still, having a grating on

the bottom, is filled to about three-fourths with the marc, then a sufficient quantity of water is poured in to prevent the marc from burning in the still. It is then closed by luting, and heat applied. The first product of this operation is very weak, and must be rectified or redistilled to produce potable brandy at 50 degrees.

The marc, thus submitted to a sort of dry fermentation, evolves an amount of heat sufficient to decompose it promptly, and cause it partly to putrefy if care is not taken to be assured from time to time whether the fermentation is completed.

A preferable method, which is adopted by some proprietors, consists of mixing the marc in a vat with tepid water at 25 to 30 degrees, to cause a new fermentation from which is drawn a light wine called *piquette*, and which is distilled separately. The marc is then distilled with a small quantity of water.

The better process for distilling the marc, in our opinion, consists in fermenting it with a small quantity of tepid water in a hermetically closed vat, then to draw off the liquid and use it to fill the still, the steam from which might be utilized for distilling the marc in a cylindrical apparatus of very simple construction. By this means would be obtained at the first jet a brandy at from 50 to 55 degrees free from empyreuma, and infinitely superior to that obtained by any other process now in use.

Brandy from the marc has a very disagreeable odor, and always retains an acid and penetrating taste which it is very difficult to remove. This insupportable taste is due to the presence of an essential oil, which, according to M. Aubergier, exists already formed in the skin of the grape, and which is not developed in the course of and by the distillation, as has hitherto been thought. This chemist, on rectifying some marc brandy in a water bath, with a very gentle heat at the beginning of the operation, and regulated so as to obtain a spirit at 36 degrees Cartier, perceived that the first portion of alcohol was partly free from the acid principle which strongly impregnated the brandy he rectified.

"I undertook," said he, "to repeat the operation, and

divided the product into three parts; the first constituting all the spirits drawn off up to the period when I ascertained that the admixture of a small quantity of water caused it to become a little milky; I changed the receiver, and that which came over, until it became necessary to increase the heat sufficiently to cause the liquor to flow in a continuous thread, constituted my second product. After having continued the heat in order to draw off all the alcohol contained in the liquor, I obtained for my third product only a thick milky liquid.

"I took the first product, and after repeated distillations with gentle heat, I obtained an alcohol almost free from the odor of marc brandy. I conceived the hope, that on repeating the rectification I might obtain a spirit absolutely free from this bad taste, but I tried in vain through three other operations; my alcohol has not the most agreeable flavor, and I think it altogether impossible to free it from a principle so tenacious.

"I redistilled the second product many times with a gentle heat, so as to draw off one nearly three-fourths of a tolerably pure alcohol, and the rest highly charged with oil. Finally, on rectifying the third product, I obtained one-third of alcohol like the foregoing; I then added the last fourth of the second product to the remaining two-thirds, thus highly charged with oil. In subjecting this to a new distillation the first portion obtained was scarcely troubled on being mixed with water, an evident sign that it contained very little oil. The second, which I permitted to run so long as it was limpid, contained a much greater quantity of oil, the presence of which was easily detected by pouring the spirit into water, when it was immediately clouded. Here I changed the receiver and continued the distillation, but at the end of the operation I only obtained a milky liquor, having on its surface a thin stratum of oil, notwithstanding, this last product was at twenty-three degrees by the areometer of Baumé.

"Finally, on re-uniting this last product to the second and adding enough water to reduce the mixture to fifteen degrees of Baumé, the liquor became at once very

opaque, and was, a quarter of an hour afterwards, covered with quite a considerable quantity of oil, which I collected with the greatest care. It appears to me that this oil is entirely volatile, since after more than ten distillations it has not left the least trace of its presence in the residuum remaining in the water bath. I may also remark, that this residuum having been subjected to very violent ebullition, was impregnated with neither the taste nor odor which characterize marc brandy.

"This oily principle has all the properties of the essential oils; its peculiar aroma, the acrid and insupportable taste which is also peculiar, prevents its being confounded with any of its kind, and authorizes me to give it the name of *volatile oil of the grape.* The following are its chemical properties:—

"1. It is very limpid and without color at the moment of its separation from the alcohol; but light causes it in a short time to assume a light lemon tint.

"2. Its odor is penetrating, its taste is very acrid and insupportable; both the odor and taste are peculiar to it.

"3. It is very fluid.

"4. It burns with a blue flame, diffusing in the air the odor of marc brandy.

"5. When subjected to distillation the first portions which are volatilized preserve the aroma, but the product acquires an empyreumatic odor, which causes me to suspect that it may contain a small quantity of fixed oil derived from the seed. The liquor contained in the retort very soon acquires a lemon color which deepens during the operation, and leaves a very light but inconsiderable carbonized residuum, which induces me to believe that this volatile oil is somewhat less light than others.

"6. It dissolves in one thousand parts of water, imparting to it both its odor and taste.

"7. It dissolves sulphur when in a state of ebullition, and deposits it when cold.

"8. Finally it forms soaps with the alkalies.

"I obtained nearly 32 grammes of this oil from 150 litres of brandy.

"Its aromatic odor *sui generis* caused me to think that it was not, like empyreumatic oil, the product of distillation, as has been believed up to the present time, but rather a volatile oil peculiar to the grape, and which must have its place in one of its parts.

"I then distilled all of the parts of the grape one after the other and separately.

"The seeds diluted with alcohol yielded quite a transparent liquor, having the very agreeable flavor of the almond. This same almond flavor is also reproduced by a distillation of grape seed with simple water. It is not, then, the seed which imparts to marc brandy the unpleasant flavor which characterizes it. The stems, when distilled, only produce a very slightly alcoholic liquor.

"But the skin or envelope of the grape, when separated from the seed and the berry, and alone subjected to fermentation and distillation, yields a brandy altogether like that from the marc. Therefore, I repeat, the disagreeable taste of those brandies does not come from an empyreumatic oil which is the product of distillation; it is not due to acetic ether; nor yet, is it the effect of an oil contained in the seed, as has been published for many years. Its true cause is a volatile oily substance, contained only in the skin of the grape, having a taste and odor so acrid and penetrating that a single drop is sufficient to infect ten litres of the best brandy, and hence, I conclude that the brandies of Cognac and Andaye are superior to others, because they alone are obtained from the distillation of white wine, which, not being fermented on the grape, is not charged with this oil, which is the product of the skin alone."

M. Aubergier has also made many very interesting experiments in regard to the vinification and purification of brandies from wine and marc. He draws the following conclusions from his experiments:—

1. There exists a volatile oil of the grape.
2. This oil exists only in the envelope of the grape.

3. It is this oil, improperly called empyreumatic, that infects the marc brandies.

4. On fermenting the must, separate from the pulp, the skin, and the seeds, in hogsheads having no other opening than that necessary for the escape of the carbonic acid, a wine will be obtained, the distillation of which will yield the largest results in brandy of the best quality.

5. Two kinds of brandy may be obtained from this same marc. That obtained by washing will be equal in quality to the wine brandy, and the other will be no worse than ordinary marc brandy.

6. If magnesia is macerated with marc brandy from which a greater portion of the essential oil has been already removed, it will be completely purified.

Distilling Apparatus of M. Villard, of Lyons.

M. Villard, of Lyons, has two kinds of apparatus specially intended for distilling the marc of grapes and other solid or semi-fluid substances which contain alcohol. These apparatus will yield products far superior to those obtained from the common still. Indeed, until the invention of M. Villard became known, a peculiar coppery taste, and a greenish tint, were the inseparable characteristics of marc brandy. This disagreeable flavor might have been called the taste of the still. Some savants, among others M. Aubergier, attributed this to an empyreumatic oil, or to a volatile oil, derived especially from the skin of the grape. These hypotheses were powerless to explain the coppery taste and the greenish tint which indicated the presence of copper. The experiments made by Mr. Higgins, of Jamaica, upon molasses, which, when heated by the common methods, gives this empyreumatic taste, persuaded M. Villard that it was due to the solution of copper in the acetic ether, which, according to this chemist, is produced by the distillation of substances brought too directly in contact with a brisk fire, having a heat of 400° or 500°. If the vaporization of alcohol can be effected by means of an

agent which does not yield so great a degree of heat, the steam of water, for example, which does not exceed a temperature of 100°, it is to be presumed that this heat being sufficient to vaporize the alcohol which is volatilized at 78°, cannot develop either the empyreumatic or peculiar oils of M. Aubergier, or the acetic ether of Mr. Higgins.

M. Villard then determined to heat the substances to be distilled by driving through them a current of steam, which, by rapidly penetrating the strata of marc, as it were molecule by molecule, might disengage the alcohol without permitting, at the same time, the formation of essential oils or acetic ether.

He has succeeded, not that he pretends to have entirely removed the taste which is peculiar to marc brandy, but his productions have neither the coppery taste, the greenish tint, nor the flavor of still, which is so remarkable in others, and which constitute a great part, if not the whole of the disagreeable flavor that affects this kind of spirits.

Doubtless, the idea of continuous distillation by steam is not new, for many manufacturers have employed it; for a long time it has been public property. But inventors, whose principal object was the manufacture of trois-six, only occupied themselves with producing, by a continuous process, steam more or less saturated with alcohol, which, on leaving their receiver, was directed into the apparatus where the separation of the vapors was effected by the aid of coolers, more or less ingenious, but always metallic.

In 1847, M. Villard conceived the altogether novel idea of bringing into service, as a condenser, the substance under treatment.

Alcohol is vaporized at 78°, and water only at 100°. If under the ordinary pressure of the atmosphere we direct into the bottom of the mass, a current of steam which very readily unites with alcohol, it is clear that the mass, when heated to 78°, will disengage its alcohol alone, until it has attained 100°. When this maximum temperature is reached, it will evolve the steam of water mixed with the alcohol that has not been driven off at a lower temperature, either because of its more

intimate union with the particles of the material under treatment, or because the temperature has been raised too rapidly for it to escape.

It is proper, then, to heat the mass containing alcohol rapidly up to 78°, by the assistance of any medium which may serve as a vehicle for the alcohol in quantity, may unite with it readily, and which may be separated from it without difficulty; then to retard the elevation of the temperature to 100°, as much as possible, or to reduce it below that degree, if it should be unintentionally reached.

If the steam is driven into the more or less cold mass, the problem will be solved, and all the distillable spirit will find its way into the coil, if the following precautions are taken, viz.:—

1. To effect the elevation of temperature slowly, progressively, and regularly, by making the refrigerant more compact and compelling the heat to penetrate it, layer by layer, or rather, atom by atom, which will enable the substance most easily vaporizable to escape first.

2. To maintain the temperature below 100 degrees by an equally cold obstacle, which must be heated by it.

The marc of the grape is well adapted to perform this office. A cold material, finely divided and penetrable, it may be compelled to take any desirable form or density. Why may it not then serve for a purifyer and condenser as well as metallic substances? It is only necessary to arrange it in closely packed layers, to heat it slowly, and to press it somewhat against the vessel containing it so as to increase the adhesion and force the steam to follow a regular course of which the operator may be certain; for two bodies of different densities, like metal and marc, are never as completely united at their points of contact as two bodies of the same nature and the same density, and an agent thrust between them by any impelling force will support itself upon that which affords the strongest resistance to force a passage through the other, and find a way of escape.

It is, therefore, evident that if the idea is adopted of employing the marc, or other solid substance, as a purifier

and condenser, it is absolutely necessary, in order to its realization, to resort to its rational and methodical arrangement by packing regularly, and forcing it against the walls of the containing vessel. It is in this that the new invention, first conceived by M. Villard in 1847, consists, and of which his apparatuses of the present day are at bottom a new but very much improved application.

The peculiar advantages presented by the apparatus of M. Villard will be so apparent to the educated and practical distiller, that we consider it scarcely worth while to go into any lengthy discussion of the subject. We may, however, remark that, in theory, his apparatus rests on three essential principles:—

1. Uniformity of pressure (one atmosphere).

2. A progressive difference in the specific gravity of the alcoholic vapors; alcohol being lighter than phlegm, phlegm lighter than water; the vapor of water being heavier than the vapor of the other two pushing them before it.

3. The difference between the degrees of heat necessary to the evaporation of alcohol and water.

The application of these principles leads to a distillation by analysis, in which the substance treated plays the part of condenser.

The apparatuses used by M. Villard are of two kinds. The first consists,

1. Of a steam generator of any convenient form.

2. Of three distillatory vessels having movable covers to facilitate the charge and discharge. They are connected by pipes furnished with stopcocks, to convey the vapor at will from the upper part of one to the lower part of another.

3. Of a cooling coil connected with an alcoholic pipe, which is common to the three vessels. (See Fig. 2, Pl. VII.)

Description of Apparatus (Fig. 2, Pl. VII.):—

1. Distillatory vessels for receiving the solid materials.

2. Pipes of communication between the vessels, from the top of one to the bottom of the other.

3. Covers of the entire breadth of the vessels, and closed by screw clamps.

4. Cocks attached to the pipes 2, and serving to direct the alcoholic vapor at will into the cooling coil, when at the commercial standard, or into the bottom of the next vessel, if in the state of phlegm or low wines.

5. Alcohol pipe. This pipe, common to the distillatory vessels, serves for conveying the spirituous vapors to the cooling coil.

6. Discharge cocks for the distillatory vessels, for drawing off the water resulting from condensation.

7. Alcoogène, or analyzing cylinder, the object of which is to prevent foreign substances from passing into the coil with the spirits.

8. Flake stand or coil cooler.

9. Cooling coil or worm.

10. Steam generator (a tubular boiler).

11. Steam box.

12. Safety valve.

13. Steam pipe, conveying the steam from the boiler to the distilling vessels. This steam is delivered into a box common to three other pipes, which conveys it to each of the vessels.

14. Steam pipes connecting the secondary box with each vessel.

15. Carriage on which the apparatus is moved from place to place.

The material to be distilled being methodically arranged in each vessel, in one or more layers of greater or less thickness according to its character, is heated by steam from the boiler. The steam, by its ascensional motion, removes all the alcohol it contains.

The condensation and return of vapors, occurring as the parts of the mass are penetrated, the more highly spirituous vapor, being the most volatile, will be the first to escape into the cooling coil.

This method of distillation, then, is divided into two stages. In the first all the good brandy, that is, the commercial article, is obtained. In the second the phlegm is distilled through fresh materials, which condense it afresh, but at the same time it serves for heating the mass.

From the explanation just given, we may readily conclude that there is much economy in this method of distillation, since the phlegm, which in the common apparatus, unprovided with a metallic rectifier, constitutes about one-half of the whole product, is thus distilled without loss of time or fuel.

The charging and discharging is managed very readily.

The second apparatus, which was constructed more particularly with a view to the distillation of beets, depends on the same principles; *the condensation of the alcoholic vapors by the material to be treated.* The means only differ.

Instead of three vessels communicating with one another as in the former, the latter consists of a single column, but so arranged that the charge is continually made at the top and the discharge at the bottom, without causing the least interruption to the distillation.

The product is of a constant alcoholic degree, and, as we have said, the flow from the coil is uninterrupted. The following is a description of the apparatus. (Fig. 1, Pl. VII.)

1. Distilling column.
2. Steam chamber.
4. Hurdles or baskets containing the marc, beets, or other solid matter.
5. Toothed rack for assisting in the removal of the hurdles.
6. Feed pump for the steam boiler.
7. Steam boiler.
9. Alcoogène for the same purpose as the corresponding piece in the first apparatus.
10. Flake stand and coil.
11. Carriage for transporting the apparatus.

This apparatus presents decided advantages over the other, whenever large quantities of material are to be heated.

Both are portable when of small dimensions (the illustrations are for the portable apparatus: modifications which a stationary apparatus would require will naturally suggest themselves), and at the present time

are fully sanctioned by experience; a number of them being in operation both in France and in other countries.

Moreover, the numerous infringers of his patents, which M. Villard has sued to conviction and damages during the last few years, are the best evidence of the value of his apparatus.

The price varies from 3000 to 20,000 francs, and the minimum of production is never less than 5 hectolitres of spirit of 50° or 55° Cent.

Although more especially intended for the distillation of solid materials; both of the apparatuses of M. Villard may, with some slight modifications be adapted to the distillation of liquids.

Cider Brandy. Apple Brandy.

Cider is the fermented juice of apples, and is in some countries a very common drink.

The manufacture of cider is as easy and more prompt than that of wine. Its quality is influenced by many circumstances, of which the principal are: the variety, the ripeness and crushing of the fruit, the fermentation of the must, &c.

The varieties of apples are very numerous, but it is not a matter of any importance to particularize them further than to say that, for the manufacture of cider, they may be divided into three classes.

1. Acid (or sour) apples.
2. Sweet apples.
3. Rough apples.

These classes are further subdivided into:

1. Early apples.
2. Late apples.

Acid apples yield much clear juice, of little specific gravity, producing a cider without strength, of not very pleasant taste, and always liable to become turbid, or as they say in Normandy, to *kill* itself.

Sweet apples produce but little juice without the addition of water; furnish a clear and pleasant cider, so long as it is sweet, but which becomes bitter and but little alcoholic when the fermentation is advanced.

Rough apples, that are bitter and harsh to the taste, yield a very dense, highly-colored juice, which ferments for a long time, and which produces a generous cider, susceptible of long preservation.

The early apples produce quite a pleasant, clear cider, but of poor color and but slightly spirituous, and which can hardly be preserved for a year.

Finally, late apples of good varieties yield a generous cider, which may be kept a long time.

The fruit is harvested, says M. Girardin, in September, October, or November, according to its time of ripening, whether early, medium, or late. It is left in a pile for a certain time, to finish ripening, and in order that it may furnish a more saccharine must. The apples are then *crushed*.

This operation is effected sometimes by means of a vertical stone wheel moving in a circular trough by the power of a horse; and sometimes by a small mill composed of grooved cast-iron cylinders, surmounted by a hopper. The pulp is submitted to the press three several times, between layers of straw, or, better still, between sheets of hair-cloth. The juice from the first pressure is what is called *strong cider*; that from the two last constitutes *small cider*. It is very weak, because the pulp has been twice mixed with a certain proportion of water.

The juice of apples consists of much water, a small quantity of sugar, a natural ferment, vegetable albumen, a peculiar coloring matter, traces of pectic acid, gallic acid, the malates of potash and lime, a considerable proportion of mucilage, and free malic acid. When the seeds are crushed they communicate to the must a bitter principle and a little essential oil.

The juice is poured into hogsheads with a large bung having a capacity of 600 or 700 litres, where it very soon sets up the alcoholic fermentation, which continues for two or three months. When it is finished, the clear cider may be used as a drink. But if a more agreeable cider is wanted, it should be drawn off into a clean vessel, one month after being expressed, and this should

be continued month after month until it is finished. For effervescing cider, it is left in the hogsheads only a month when the clear liquid is drawn off and bottled.

Usually cider made in summer is potable for four to six months; that made in autumn for six to ten months, and that made during the winter, from ten to twenty months. The best ciders cannot be kept in good condition more than three or four years.

The districts in which cider brandy is more particularly manufactured are Normandy, first; then Picardy and Brittany. The distillation is conducted by the same methods and apparatus as for wines.

As with the alcoholic richness of wine and other drinks, so does that of cider vary according to the season, the ripeness and variety of fruit, &c. It is by no means unusual to obtain nine per cent. of pure alcohol from some ciders, while there are others which yield only four or four and a half per cent.

Ordinarily from seven to eight litres of pure alcohol are obtained from one hectolitre of *old cider*, or about fifteen litres of brandy at 50°. But these results may be greatly increased if the fermentation is conducted on the principles we have set forth, and a certain proportion of water added to the juice, so that it shall not mark higher than six degrees by Baumé's areometer; the fermentation will then be more active and more complete.

Cider brandy has a strong and disagreeable odor, due partly to the presence of malic acid, which may be removed by rectification, but which consumers prefer. Thus, in Lower Normandy, where the manufacture of apple and pear brandies is still in its primitive state, the spirit they obtain is not at all comparable to that obtained from wines, yet the Normans prefer it to the latter, and so strong is the power of habit, that they select that as the best which has the most decidedly empyreumatic flavor.*

* In many portions of the United States, particularly in the eastern counties of Virginia and the middle portions of North Carolina, distillers ferment and distil the pulp of the apple without expressing

Portable Apparatus for Continuous Distilling.

The portable apparatus for continuous distillation is altogether a recent invention of M. Egrot, yet it is already introduced on many farms in France and other countries. Simple, light, and yielding products of good quality, it appears to be well adapted for use, particularly on small or medium-sized farms. It should be highly prized in Normandy for distilling cider, and in the South for wine. It is sufficient to set up the apparatus near the shed in which the liquor to be distilled is stored, and then to pump the liquor through pipes of sufficient length into it.

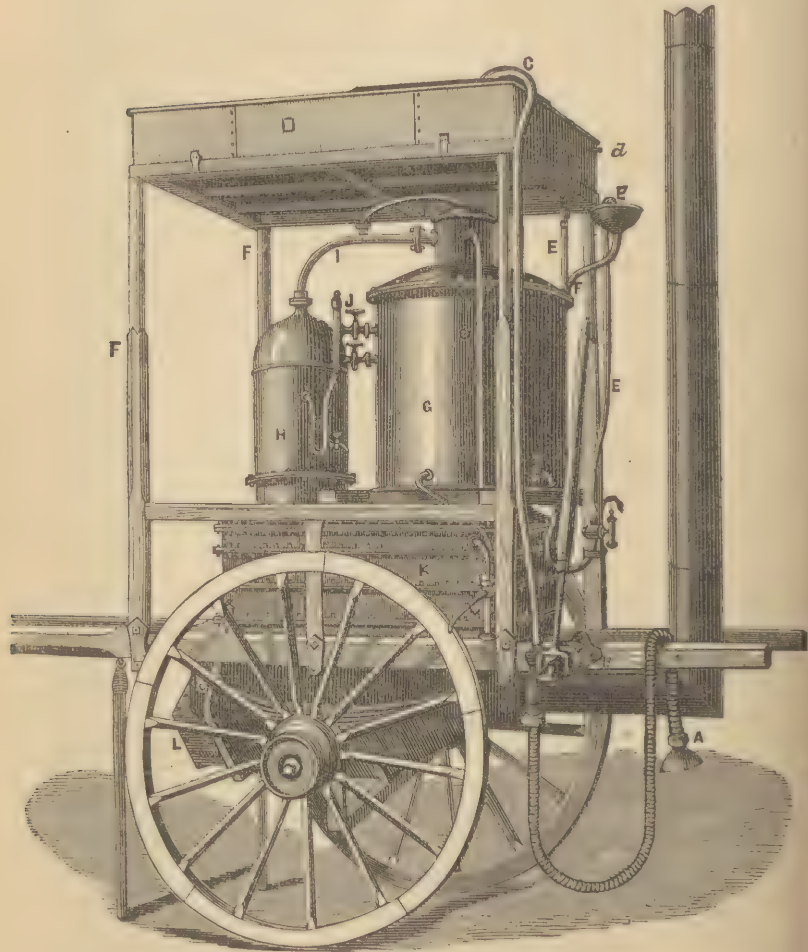
This apparatus is no more than the stationary system of the same inventor, so modified as to render it capable of being worked on a carriage, and thus become portable. M. Egrot affirms that it adds the facility of transportation to the advantages presented by large distilleries, since the distillation is promptly accomplished, and the exhaustion of the liquor is complete. It yields at the first jet, brandy at 50 degrees, and rectified alcohol at 90 degrees. Besides, it is set up very easily so that it may be put in operation immediately on its arrival at a place. Finally, it greatly economizes fuel. There is no necessity for enumerating the advantages which small proprietors would derive from the use of a machine of this kind, which may serve many crops and can be transported from one farm to another in time or as wanted. M. Egrot constructs portable distilleries of different sizes. The smallest, treating 30 hectolitres in twenty-four hours, may be drawn by a single horse. The larger apparatus requires for its transportation on a good road one horse, but two horses are always sufficient, even where the roads are in bad condition.

To enable the reader to understand more fully the

the juice. Thus producing a poisonous compound of alcohol with essential and empyreumatic oils, nauseous beyond measure, and fraught with disease and death to those who are so unfortunate as to have acquired a fancy for a drink so abominable. It is called *pug*, or *pulp brandy*.—*Translator*.

arrangement of the machine, we offer the accompanying illustration and description.

Fig. 3.



L. Copper boiler surrounded by a sheet iron furnace.
M, *K*. Distilling plates.
H. Rectifying column.
I. Goose-neck for conducting the alcoholic vapor from the rectifying column to the wine-heater *G*.
G. Cooler and wine-heater combined.

J. Pipe and cocks for the return of the spirits to the rectifier.

E E'. Funnel and pipe to receive the wine and convey it to the bottom of the cooler.

A B. Suction and force pumps to feed the reservoir *D*.

C. Pipe to convey the wine from the pump to the reservoir *D*.

D. Reservoir or tank surmounting the apparatus and to receive the wine.

F. Supporters for the reservoir.

d. Level pipe to the reservoir.

The distilling is conducted as follows:—

The liquor to be distilled, let it be wine, is raised to the upper tank *D* by means of the pump *B* attached to the frame of the carriage; the regulating cock of the pipe E is opened, and all the parts of the apparatus are filled except the boiler *L*, which has been previously filled with water.

The regulating cock is then closed, and the fire lit under the boiler. The steam which rises, passes first over the first plate *M*, where it takes up a certain quantity of the vapor of alcohol; by traversing the second plate *K* it is enriched by a second dose of alcohol; finally, it is saturated in the third compartment. This vapor, highly charged with alcohol, reaches the rectifying column *H*, where it is freed from a greater portion of its water and its essential oils; thence it is conveyed by the goose-neck *I* into the coil of the cooler *G*, the upper portion of which acts as a rectifier. The alcoholic vapors which have found their way mixed with the steam into the cooler, return to the rectifying column by the pipe *J*. The vapors which are not condensed in the upper part of the cooler are condensed as they descend and escape in the form of brandy or alcohol as the return cocks may be closed or open.

At this moment the regulating cock is opened. The liquor contained in the reservoir entering at the bottom of the cooler, raises the wine already heated by contact with the worm, and causes it to flow into the pipe which leads to the upper section of the still; there it is subjected

to the action of the steam rising from the boiler, which deprives it of a portion of its alcohol; it loses the balance of its alcohol in traversing the two other sections; it finally falls into the boiler as spent liquor, and by its ebullition furnishes more steam for continuing the distillation, and so on. The exhausted liquor escapes from the boiler in a continuous stream through a waste pipe in form of a siphon.

To terminate the operation, water is pumped into the upper reservoir. This water forces before it all the wine which the apparatus contains, and when the proof bottle no longer indicates the presence of alcohol all the stopcocks are closed, the fire is extinguished, and the machine left in this condition until the work is resumed, or if this is to be postponed for a long time, or the machine has to be removed to some other place, it will be necessary to empty it entirely of water.*

Pear Brandy.

Perry is a drink prepared from pears just as cider is from apples, and between which, too, there is much analogy. The action of perry on the nervous system is thought to be injurious. It is less nutritious and more irritating than cider. It is very heady when old, and promptly intoxicates those who are addicted to its habitual use.

Pears yield nearly fifty per cent. more juice than apples, and the juice is far more saccharine; perry, also, contains more alcohol than cider. Perry of the best quality is very like the white wines of Anjou, Sologne, and Gatinais. When bottled, after being well prepared, it becomes entirely wine-like. When it is effervescent, it often resembles the light wines of Champagne. It is well suited for mixing with white wines of inferior qua-

* There is an apple and cider mill manufactured by Messrs. H. M. Smith & Co., of Richmond, Va., which reduces the apples to a very fine pulp in a very short time, and delivers them directly into a frame or slatted box, over which is placed a screw to act as a press. Those who have tested this machine by its practical application speak of it in the highest terms. It may be driven by hand or horse power.—*Translator.*

lity, which it renders stronger and better, as is well understood by wine dealers; frequently, small retailers even sell pure perry as white wine.

Pear brandy is obtained in the same way as cider brandy, and possesses the same characteristics. The alcoholic results, as in all other drinks, cannot be positively estimated, this depends on the good or bad quality of the pears, whether they are carefully handled or not, the temperature, &c. Nevertheless, we may say that it is quite common to obtain 15 or 18 per cent. of brandy at 50 degrees from perry.

Brandy from Beer.

Beer is produced by the fermentation of barley and a decoction of hops; like all other fermented liquors, it contains more or less alcohol, and will yield a brandy of pretty fair quality when it is itself of a good quality, and when the distillation is effected by steam, but which still preserves a peculiar odor and taste due to the hops. Generally the quality is bad, as only spoiled beer is distilled; good potable beer will always command a higher price than the brandy it will yield. The distillation too is always conducted over the naked fire, and proper precautions are not taken to prevent the slimy and mucilaginous elements of the beer from being burned to the still, which, by adding a detestable empyreumatic flavor to the acid taste of the spoiled beer, must cause the product to be bad.

When beer is distilled the operation should be conducted in the same manner as for wine.

There are many other fermented liquors which will yield alcohol by distillation, as *hydromel*, &c., but the inferior quality of the spirit produced, and the expense attending the use of many of these substances have induced distillers to pass them by for those in more general use, and the profit from which is less problematical.

Rum.

The names *rum* and *tafia* are applied to a spirit obtained from the distillation of a fermented liquor prepared from

the molasses of sugar cane. This spirit is of excellent quality, and is very much sought after when it is old.

Rum comes to us from America, principally from the Antilles; Martinique and Guadaloupe furnish it in large quantities of very good quality.

True *Jamaica rum* was formerly made from the juice of the violet cane, which gave it a peculiar aroma, and *tafia* was the product of the distillation of molasses; now both of these liquors are obtained from the distillation of molasses, only the article sold as rum is the spirit of molasses carefully prepared, while that sold as tafia has less perfume and is of inferior quality.

Rum is shipped from the colonies in iron-bound oak barrels containing 225 or 425 litres: its alcoholic strength is commonly from 51 to 55 degrees Centigrade. It is much used in France and England, where it is considered as a preservative against cholera.

This distillation of rum like all the operations accompanying it, is conducted in the same way as that for the distillation of alcohol from molasses, only by preference a special apparatus (see page 76) is used in order to retain in the rum the characteristic taste which causes it to be so highly prized by *gourmets*. The first product is never of sufficient degree; it is necessary, then, to redistil it.

Like all other spirits, rum when it is first distilled is white and transparent; in order to give it the yellowish amber tint by which it is known in the trade and to increase the peculiar taste usually met with in it, variable proportions of prunes, shavings of leather, cloves, tar, etc., are infused in a part of the liquor: the desired color is generally completed by the addition of the necessary quantity of caramel. The proportions of the ingredients just named constitute what are called in the rum factories *sauces*. They differ in different factories, and from this results the various kinds of rum, which connoisseurs esteem more or less for their peculiar bouquet. The following is the recipe for one of these sauces:—

New leather tanned and rasped	2	kilogrammes.
Oak bark crushed	500	grammes.
Cloves	15	"
New tar	15	"
Molasses spirit	100	litres.

Infuse the whole for fifteen days, then draw off the clear liquid and complete the color with caramel.

Another method consists in infusing the other ingredients in a small quantity of the spirits, and using the tar in a different manner. It is as follows:—

Shavings of tanned leather	4	kilogrammes.
Black truffles	1	"
Orange peel	20	grammes.
Alcohol from molasses at 85°	10	litres.

Digest at least fifteen days before using this preparation, and only add enough of it to the rum to perfume it properly, then introduce into the cask destined to contain the rum the smoke from a wisp of straw impregnated with tar; now close the bung in order to allow the vapor time to condense on the surface of the cask, then fill it with the prepared rum. This, when old, acquires a flavor very analogous to that of Jamaica. It is well to add a small quantity of caramel to give the usual amber tint.

Prunes are used even during the fermentation; they are steeped in hot water, and after being crushed, are thrown into the fermenting vat. The proportions are very variable, but generally 10 kilogrammes of prunes are added for every 100 kilogrammes of molasses: that of the hot water is also indefinite.

By reason of the facility with which rum may be mixed with spirit of wine, it is rarely met with unless so mixed, especially in the hands of a dealer. This fraud is difficult of detection; there are a few dealers in spirits who can detect it, and they are frequently deceived.

Kirschenwasser or Kirsch. (Cherry Brandy.)

In Germany, the spirit distilled from the fermented juice of a variety of wild cherry, is called *Kirschenwas-*

ser (cherry water), which is contracted into *Kirsch*. A great quantity is produced in the Black Forest, from which the best kirsch of Germany and Switzerland comes.

In France, the distillation of kirsch is confined almost exclusively to Franche-Comté, that is, to a small portion of the departments of Haute-Saone, Vosges, and Doubs. The centre of this trade is at Fougerolles (Haute-Saone), where there are many commission agencies of importance, both French and foreign.

The cherries generally employed for making kirsch are a species of wild cherry, the fruit of which is very black when thoroughly ripe, and with a long red stem, and a very large seed in proportion to the fruit. They are collected in July and August. If possible, a fair day is selected; because it is well understood that kirsch from cherries gathered in bright weather is far better than that obtained from fruit gathered during a damp spell.

Generally, the method of manufacturing kirsch is very objectionable. When the cherries are ripe enough to be readily plucked by hand, one by one, as is indispensable to avoid unripe fruit, the peasants thrash the trees with long poles, while the children gather the fruit as it falls and throw it into open hogsheads. One may well see that in this mass there will be some cherries insufficiently ripe, and some that are rotten; yet there is no separation, and the whole are mashed together, either with the hands or a small wooden block on a wicker strainer, resting on two pieces of timber, placed on the top of the fermenting vats, which receive the expressed juice; they then pound the marc with a view to crushing the seeds, and throw it into the expressed juice, in order that, during the vinous fermentation, it may impart the agreeable taste which is characteristic of kirsch, and which causes it to be so much sought after.

When the fermentation is finished, which requires from fifteen to thirty days, according to the capacity of the vats and the temperature of the weather, they throw

the whole, marc and liquid, into the Turk's-head still, and distil over a naked fire. This process, as we see, is very defective, and can only result in a product of very bad taste, and is highly injurious to the animal economy; because, on one hand, the cherries, being left to ferment in vats, or hogsheads usually on end, open at the top, and but seldom, or imperfectly covered, become acid, and often mouldy on the top. On the other hand, the distillation of a semi-fluid substance over a naked fire, produces an empyreumatic flavor, which the crushed seeds are intended to conceal, however, without entire success.

The best process for obtaining kirsch of good quality is the following:—

The cherries, when ripe, are plucked singly by hand, only the ripest being gathered; in this state they only are taken that will separate easily from the stems, which are left attached to the tree. Those that are rotten or damaged should be rejected. As soon as a sufficient quantity of fruit is gathered to justify operations to be commenced, it is crushed by the hands, or a wooden rubber, on a wicker basket or trough, supported by a frame resting on a tub. The juice falls into the vessel, while the skins and seeds remain in the basket. The seeds, being separated from the skins, are thrown into the liquid, and the whole transferred to a fermenting vat; it is carefully covered, and permitted to ferment in some place having the proper temperature. The must commonly marks six or seven degrees Baumé, and the fermentation, which lasts about four or five days, is effected without artificial ferment. When the fermentation is finished, the clear liquid is drawn off and distilled, with all the necessary precautions, by the aid of steam.

All spirits from nut fruits, may be prepared in the same manner, especially that from prunes, which possesses much analogy to kirsch, and is often confounded with it.

Well prepared kirsch has a peculiar flavor, which is not empyreumatic, but which is derived from the seeds;

it is not acrid; the odor is due to the presence of a small quantity of hydrocyanic (prussic) acid, contained in the cherry stones. For a long time, it was thought that the stones ought to be broken, to produce in kirsch its characteristic odor and taste; but it has been ascertained that this is altogether superfluous, and that the seeds communicate to kirsch identically the same perfume, whether broken or not.

The alcoholic product from 100 kilogrammes of cherries is usually seven or eight litres of kirsch at 51° or 55°, or about from three and six-tenths litres to four and four-tenths litres of pure alcohol.

The larger proportion of kirsch made in Franche-Comté, is sent to market very soon after its distillation; it is then at 53° C. When intended to be kept, it is put up in glass vessels, demijohns, bottles, or flasks, etc. During the first year, the vessels are closed with some substance that will permit a slight evaporation, by which the acrid principles are volatilized, and a very pleasant liquor is left in the vessel, which is now closely corked to be kept.

When glass vessels are lacking, it is put up in small casks or kegs made of ash, which have the advantage of not imparting any color to their liquid contents. In the country they are in the habit of placing kirsch, during the first year, in rooms where a gentle temperature favors evaporation. We may remark, in passing, that colored kirsch is seldom made, it being more highly prized when limpid and transparent. Age, as for all other spirits, greatly improves its quality.

Frequently, kirsch is met with in the market mixed with pure brandy, or alcohol from apricot seeds, reduced to 51°; sometimes alcohol, reduced and perfumed with the essence of bitter almonds, is added to it; but all these frauds produce a kirsch of inferior quality, which is easily recognized by the taste.

There is, however, a preparation which imitates kirsch so perfectly, that when mixed with the latter, it is very difficult of recognition. It is as follows:—

Seeds of apricots . . .	3	kilogrammes.
Seeds of cherries . . .	9	"
Dried peach leaves . . .	625	grammes.
Myrrh	150	"
Good flavored alcohol at 85° .	62	litres.

Bruise the seeds and digest the whole together in a water bath in a simple still for 24 hours; at the moment of beginning the distillation, add 30 litres of water, lute on the top, light the fire, and draw off 60 litres of a good product, to which should be added 40 litres of water to reduce it to 50°, and thus form 100 litres of factitious kirsch. By adding 15 grammes of sugar to the litre, the taste will be softened and the sharpness of the liquor destroyed. The peach leaves may be replaced by 315 grammes of the dried flowers.

Since the advance in the price of spirits, a great many kirsch distillers mix alcohol from the beet or grain with the cherry wine. The mixture being perfect, the alcohol takes up the excess of perfume, which would have remained in the liquor, and, in consequence of its addition, the quantity of kirsch is greatly increased.

Gin. Geneva.

Gin is nothing but grain spirit aromatized with juniper berries. It is not the result of the distillation of these berries crushed and fermented with water. This spirit, then, is prepared in the same manner as whiskey, and the only object of adding the juniper is to cover the unpleasant taste which usually characterizes this liquor. The proportion of berries used is extremely variable; it depends on the nature of the spirits and the wishes of the distiller; but, as a general rule, one kilogramme of berries is sufficient for the proper aromatization of one hectolitre of whiskey.

The juniper berries, coarsely ground or simply crushed, are added to the product which is about to be distilled, or placed in a sack and suspended in the still, or, what is better yet, on a receiver arranged for the purpose, through which all the alcoholic vapors rising from the still are compelled to pass.

Holland enjoys a large trade in the exportation of its gin. Its home consumption, which is considerable, consists of a gin at 45 to 49 centesimal degrees. The large factories of this product are at Scheidam (Schnaps). This town contains more than two hundred gin distilleries.

In Sweden and Norway, a sort of gin is prepared by simply digesting the juniper berries for some days in spirits at 50 or 55 degrees. This process is very objectionable, because it communicates to the liquor a very disagreeable sharpness. It is preferable to employ the process described hereafter, which consists in distilling the berries after sufficient maceration with alcohol at 85 or 90 degrees, and to reduce the product of the operation to 49 degrees.

The gin, which is consumed in the North of France and Belgium, is often nothing more than whiskey from rye and barley, or rather from potatoes and barley, and the taste which characterizes it is that of grain. This gin has an odor which is by no means agreeable, and far from being delicate, yet it is very much preferred by those who like this kind of spirits.

CHAPTER IX.

THE MANUFACTURE OF SWISS ABSINTHE.

Swiss absinthe at the present time constitutes the object of considerable trade and a special manufacture. Portarlier, Montpellier, and Lyons, are cities in which it is manufactured in very great quantities. We shall describe the article as produced in each locality, assuming that the quantity of Swiss absinthe to be made is one hectolitre.

Absinthe of Portarlier.

Larger absinthe, dried and ground,	2 kilogrs., 500 grms.
Green anise	5 "
Fennel	5 "
Alcohol at 85°	95 litres.

Digest these ingredients for at least twelve hours in a water bath, add 45 litres of water when ready to distil, close the apparatus, and distil off 95 litres of perfumed spirit. Continue the operation until all the phlegm is drawn off, and set it aside for another operation.

The green color is given by the following process:—

Small absinthe, dried and picked . . .	1 kilogr.
Hyssop (tops and flowers), ...	1 "
Lemon balm, dried and picked . . .	500 "
Perfumed spirits, from the preceding operation,	40 litres.

Divide or cut up the small absinthe, reduce the hyssop and balm to a powder in a mortar, put the whole into a water-bath with the perfumed spirits, lute immediately, then heat gently, so as to produce a very moderate and gradual heat, and, so soon as the hand cannot be placed on the cap, withdraw the fire quickly from beneath the apparatus, in order to prevent the liquid from being distilled. Allow it to cool entirely before withdrawing the still from the water-bath, then pass the colored liquor through a hair cloth to drain the plants; add this product to the 55 litres of perfumed spirits that are reserved, and reduce to 74 degrees by adding five litres of water, which will bring the quantity up to 100 litres.

Absinthe of Montpellier.

Large absinthe dried . . .	$2\frac{1}{2}$ kilogrammes.
Green anise	6 "
Florentine fennel . . .	4 "
Coriander	1 "
Angelica seed	500 grammes.
Alcohol at 85°	95 litres.

Distil as in the preceding case. The color is made also in the same way with the following ingredients:

Dried hyssop, (herb and flowers),	750 grammes.
Dried balm of Moldavia . .	750 "
Small absinthe	1 kilogr.

Absinthe of Lyons.

Large absinthe, dried	3	kilogrammes.
Green anise	8	"
Fennel	4	"
Angelica seed	500	grammes.
Alcohol at 85°	95	litres.

Coloring.

Dried and selected lemon balm	1	kilogramme.
Small absinthe dried.	1	"
Hyssop tops and flowers dried	500	grammes.
Dried veronica	500	"

Absinthe of Fougerolles. (For 600 Litres.)

Green anise	45	kilogrammes.
Fennel	25	"
Larger absinthe	16	"
Alcohol at 85°	570	litres.
Water	300	"

Digest for at least twelve hours with the alcohol in a proper apparatus, add the water at the time of distilling, draw off 570 litres of perfumed spirits. When this quantity has been obtained continue the distillation until all the phlegm has been distilled off and set aside for another operation.

Coloring.

Lemon balm	4½	kilogrammes.
Hyssop	3½	"
Lesser absinthe	4	"
Veronica	4	"

Treat as for that first described and reduce the mixed spirits to 74° by the addition of enough water to bring the quantity up to 600 litres.

Absinthe of Besancon. (For 600 Litres.)

Great absinthe	24	kilogrammes.
Green anise	30	"
Fennel	40	"
Coriander	4	"
Alcohol at 85°	570	litres.
Water	300	"

To be treated as above.

Coloring.

Balm	3	kilogrammes.
Less absinthe	6	"
Hyssop	5½	"

Treat as the last.

Absinthe of Nimes. (For 600 Litres.)

Great absinthe	22½	kilogrammes.
Green anise	22½	"
Fennel	15	"
Coriander	2½	"
Roots of the black alder . .	1½	"
Angelica root	1½	"
Alcohol at 85°	570	litres.
Water	300	"

Treat as above.

Coloring.

Less absinthe	5	kilogrammes.
Hyssop	4½	"
Balm	1½	"
Veronica	2½	"
Mint	2½	"

Treat as before.

It is always optional to diminish or increase the quantities of the ingredients in the foregoing recipes according to the taste of the manufacturer, or the price of the article he wishes to produce; but this fact must be borne in mind, that it is only age that will give to absinthe that softness so much prized by consumers.

Remarks.—The greatest pains should be taken in the selection of the materials, especially the plants intended for the coloring; these should be very green and dry, and free from black and mouldy leaves. The seeds should be powdered in a mortar, and the great absinthe picked over and ground.

The distillation of absinthe should be effected in a Turk's-head still, in a water-bath, or, what is better, by steam, in order that the essential oils may rise with more facility, especially towards the close of the operation; because the phlegm is employed in another opera-

tion, in which it is most useful, by adding to the perfume through the large proportions of essential oils it contains.

The coloring is of the highest importance. The plants are finely divided, or reduced to powder, and covered with perfumed spirits; then heated gently, in order to extract the chlorophylle or coloring principle. After cooling, the colored spirit is drawn off clear, and the plants are drained. They may still, after this operation, serve for coloring a smaller quantity of absinthe. They are then subjected to distillation, to collect and save the small quantity of alcohol still adhering to them.

In the large factories, the extract of absinthe is colored in tinned copper vessels, containing about twenty hectolitres—they are called *colorers*. These vessels, hermetically closed, are heated to 60 degrees by means of steam.

The coloring may be made in the cold way, but the operation requires many days, and a large quantity of plants, which considerably increase the acridity of absinthe.

When the coloring and perfumed spirit, held in reserve, have been mixed, the alcoholic strength is tested and reduced to 74°, although absinthe is never sold above 72°; but, by rest and time, there is always some loss which must be provided against.

The green color of absinthe becomes yellowish by age, and then has a dead-leaf tinge. The green tint may be preserved by adding, after the mixture, fifteen grammes of *alum*, dissolved in a glass of water; but consumers generally prefer the yellow tint. By age, absinthe improves in quality, by losing its sharp and empyreumatic taste, which is communicated by the distillation and coloring.

It is to be remarked that it is not the great variety of substances introduced into the manufacture that constitutes the great merit of absinthe, but rather the rational combination of a small number having peculiar virtues: thus, the anise serves to produce the whiteness; the fennel corrects the piquant and sugary taste of the

anise, at the same time adding something to the flavor; the hyssop fulfils the same end, while it yields a beautiful green color, which the balm increases still more. Finally, the lesser absinthe, by its slightly yellowish tinge, modifies the excessive brilliancy of the green color, while its slight bitterness and aroma, added to those of the great absinthe, impart to this liquor the characteristics peculiar to a well-made product.

Absinthe is considered as being of good quality when, on being diluted with water, it becomes white, and exhibits the colors of the opal, which is due to the essential oils from the seeds, and the resinous and coloring matters of the plants, which, under these circumstances, are set at liberty, and form, with water, the milky compound so highly prized. In this state, it should be pleasant, agreeable, odorous, and sweetish. Sharpness and tastelessness are always signs of a recent manufacture.

Absinthes of inferior quality are often met with in the market. Some are manufactured without distillation, essences being used to replace the seeds and plants; some are distilled with trois-six from beets, &c., which leaves much to be desired in flavor; some are prepared with old or damaged materials, while, finally, there are others which, after the distillation have had added to them aromatic resins, such as benzoin, guaiacum, &c., in order to increase the opalescence.

White Absinthe.

Greater absinthe, selected	2 kilogrs., 750 grms.
Less absinthe	1 kilogr., 125 "
Hyssop flowers	1 " 100 "
Veronica	550 grammes
Genepi	550 "
Roman chamomile	225 "
Green anise	5 kilogrs., 250 grms.
Fennel	5 " 250 "
Coriander	1 kilogr.
Angelica seeds	550 grms.
Alcohol at 85°	96 litres.

Conduct the maceration and distilling in the same way as for green absinthe; then rectify the product, and reduce to 74°.

The abuse of absinthe, even diluted with water, is most deleterious to the animal economy. Taken pure, it occasions serious disorders of the stomach and brain. It is not to the alcohol alone that these injurious effects are to be attributed, but more especially to the large quantity of essential oils of anise and fennel which it contains.

Apparatus for Manufacturing Absinthe and Perfumed Spirits.

This apparatus, Pl. VIII., consists of the following parts:—

A. Kettle inclosed in a wooden jacket, acting as a water bath inclosing another kettle, which contains the alcohol and herbs to be distilled.

B. Top or cover of the boiler (still).

C. Opening closed by a plug for charging the still.

C^1. Opening like the above for discharging the plants after distillation.

D. Cap of the still fastened on by a circular collar, and terminating in a neck which conducts the alcoholic vapors to the cooling coil.

E. Cooler with its coil.

E^1. Discharge pipe of the condensing coil.

F. Colorer, furnished like the still, with plugs through which to fill and empty it.

G. Pump firmly fastened to the wall by the collars G^1.

H. Piston rod.

I. Eccentric for driving the pump.

J. Pulley on which a band runs to connect with the power.

K. Bearings for pulley shaft.

L. Tank, or well of metal, sunk in the floor.

M. Suction pipe.

M^1. Suction pipe connected with colorer.

N. Three-way cock, attached to the suction pipe to draw any liquid from the tank to deliver it in the still, in

the colorer, or to the store-room, or to draw the finished liquor from the colorer, and deliver it in the store-room.

N^1. Pipe for drawing off the colored product.

O. Force or delivery pipe.

P. Three-way cock, which directs liquids at pleasure into the still or the colorer.

P^1. Pipe delivering the liquid into the colorer.

P^{11}. Pipe to convey the liquor into the still.

R. Cock and pipe for delivering the manufactured product into the store-room.

S. Funnel and pipe to convey the distilled product to the tank.

T. Main steam-pipe connected with steam boiler.

U. Steam-cock for the kettle of the still.

V. Steam-cock for the colorer.

Management of the Apparatus.—The principal advantages of this apparatus are its great simplicity and the small number of pieces constituting it. One pump, by its multiplicity of uses, is sufficient for three different transfers of liquid.

1. It fills the boiler of the still *A* with alcohol and water.
2. It fills the colorer *F* with the distilled product which flows into the tank by the funnel and pipe *S*.
3. It draws the liquid from the colorer *F*, to send it to the store cisterns by the pipe *R*.

The apparatus is set in operation as follows:—

Having filled the tank *L* with water and alcohol in the proper proportions, and having placed in the boiler of the still through the upper opening the plants necessary to the manufacture of the absinthe, the cock *PP^1* is opened, and the pump set to work; the boiler *A* is immediately filled from the contents of the tank *L*. When the tank is empty, the motion of the pump is stopped and the cock *P* is closed. The steam is turned on by opening the cock *U*, and the product soon begins to flow from the lower extremity of the condensing coil, falls into *S*, and again fills the tank *L*; but now it is spirits perfumed by the plants that were placed in the still. The liquid is white, and possesses already a great

part of the properties peculiar to the liquor. It must now be colored. For this operation the pump performs its second office, by drawing up the liquid and sending it to the colorer *F*, which has been previously packed with the coloring plants in quantity proportioned to the perfumed spirit to be poured over them. The perfumed spirit is drawn from the tank *L* by the pump, and is transferred through the cock *P* and the pipe P^1 into the colorer. Finally, after this operation, which finishes the manufacture of absinthe, the pump fulfils its third office by drawing the colored product contained in *F* through the pipe N^1, and transfers it through cock and pipe *R* into the tanks or barrels intended for its reception.

Causes of the Pernicious Effects of Absinthe.

This so-called Swiss absinthe has attracted public attention for some time, and much credit is due to the writers of many scientific and medical essays, for indicating with so much persevering energy the abuses of this product, a horrible curse which is killing the youth of our colleges, decimating the army, and will cause the fatal debasement of the rising generation.

In order to increase the sale of this truly horrible beverage, the idea has been invented of mixing it with syrups of gum, so called, and which most generally do not contain a particle of gum, and which, on account of the vile method of the manufacture, only bring in their train an increase of the evil.

Of course these evils are not to be attributed to first-class houses, who only sell for consumption perfectly distilled absinthes that are free from all adulterations.

We have no intention, by what has just been said, to advise the use of this liquor, however well it may be made, but to set forth the fact that, in many localities, sufficient care is not taken in the selection of the plants, and in conducting the distillation. This results from the fact that most persons who undertake this work are ignorant of the first principles of distillation. So much is this the case, that, if allowed to express an opinion on so serious a question, we should advise the authorities—

1. To require that all liquor distillers who manufacture absinthe, or any other spirituous liquors, should have some knowledge of chemistry and botany, should be of good character, and be possessed of organs of taste and smell accurate enough to be of use in estimating the quality of the materials passing through their hands.

2. That a certificate or diploma as a distiller should be conferred on him only after his having proved, by a satisfactory official examination, that he is possessed of a competent knowledge of the theoretical principles of the trade he wishes to pursue.

3. Finally, that he should serve for at least one year as an apprentice, in order that he may, on entering into the business, add also practical knowledge to the theoretical which he should possess. By following this plan, we would have good and true distillers. While at the present time a large proportion of the young men, who set up in this business, have very little knowledge, they very often leave trades having little or no connection with distilling, and at the end of a few months' apprenticeship, sometimes under a man more ignorant than themselves, they present themselves as master workmen at the distillery or the brewery. Why, then, should it be cause for astonishment if badly manufactured products of distillation enter into our daily consumption?

We cannot close this article without giving some advice on the distillation of absinthe.

The plants should be picked over, as only the tops are distilled, and the flow phlegm should never be pushed to the end of the distillation. It may be objected that the liquor will be less penetrating, and will have less bouquet; we answer, so much the better for the consumer. They may rejoin that the price will be much higher: we reply, what is the difference? it will sell all the better for that.

We cannot omit to recommend the use of *calamus aromaticus*, and angelica root in the proportion of 125 grammes to the hundred litres of the product, with balm, hyssop, and the small absinthe for the coloring, which should always be made hot.

But why are absinthes so bad in Paris? It is because the greater proportion of absinthes sold are not distilled, but made from essences, which, as is well known are highly charged with empyreumatic essential oils. Now, if the proportion of these essences is too great, as is almost always the case, they are not completely dissolved, and the absinthe so manufactured, after being swallowed, leaves an acrid taste, and a lasting and painful sense of heat and discomfort in the mouth, throat, stomach, and even in the urinary organs in persons who use it habitually.

In conclusion, absinthe, as a medicine, like most other plants, has some useful properties; but as a favorite and daily drink it has its dangers and becomes very often fatal. But it is certain that if this liquor was always of good quality and properly prepared, it would not play such sad havoc, and would spare many useful men to the country.

CHAPTER X.

ALCOHOLOMETRY.

SPIRITUOUS liquors, known in commerce as brandy, whiskey, spirits, etc., as we have already said, are mixtures of alcohol and water in variable proportions. Their marketable value generally depends on the actual quantity of alcohol which each of them contains.

Alcoholometry is the determination of the alcoholic strength of spirituous liquors, that is to say, the valuation of the proportions of water and pure alcohol that a mixture of these two liquids may contain. This is effected by the combined use of a thermometer and an areometer. As for the valuation of the proportion of pure alcohol contained in a wine, or any liquid whatever, it is made by the assistance of small test stills. Before examining the latter, we shall first explain the method of determining

the proportion of alcohol contained in a mixture of pure water and spirit, and describe some of the instruments necessary to the solution of this problem.

Thermometers.

Thermometers are philosophical instruments made use of to determine the temperature of the atmosphere and of different substances with which they may be brought in contact. These instruments are graduated glass tubes hermetically closed, which contain a certain quantity of mercury or alcohol. The construction of the thermometer depends on the property common to all substances by which they expand under the influence of heat, and contract under the influence of cold.

The thermometers used in France are *Reaumur's* and the *Centigrade*. The latter is the official thermometer, and is coming more and more into use. In Germany, England, and the United States *Fahrenheit's* thermometer is used.

In order to compare two thermometers one with the other, it is necessary to have two fixed and invariable points of reference; the temperature of melting ice has been chosen for one, that of water in a state of ebullition at the level of the sea for the other; because these two terms are the same everywhere, and are easily found.

The three thermometers named have not the same divisions, but are as follows:—

Reaumur,	the freezing of	water	0°,	boiling	water	80°
Centigrade,	"	"	0°,	"	"	100°
Fahrenheit,	"	"	32°,	"	"	212°

In Russia, the thermometer of *Delisle* is used; the scale is the reverse of the above; the boiling point of water is zero, and the freezing point is marked 150°.

Mercurial thermometers cannot be constructed to indicate a temperature, above 350°, because that liquid boils at this temperature, nor below 34° below zero, because when so near its freezing point its rates of expansion and contraction are irregular.

The distiller has frequent use for the thermometer in the various operations we have described. When the instrument is to be used, it is sufficient to suspend it for a while in the air or the liquid the temperature of which is to be tested. The fluid in the instrument will soon stand at a fixed point, thus indicating on the scale attached the temperature sought for. It is proper to remark that mercury acquires the temperature of a liquid much more readily than that of air, so that it is necessary to wait a longer time when testing the temperature of the atmosphere than is required for liquids. Mercurial thermometers are to be preferred to those filled with alcohol on account of their greater accuracy and the promptness with which they react under changes of temperature.

As each may have his own fancy as to the thermometer he may prefer to use, we have thought it advisable to subjoin the following tables, showing the relations between those in use among different people in various countries.

TABLE *converting the Degrees of the Centigrade Thermometer to Degrees of that of Reaumur, and* vice-versa.

Centigrade.	Reaumur.	Centigrade.	Reaumur.	Centigrade.	Reaumur.	Reaumur.	Centigrade.	Reaumur.	Centigrade.	Reaumur.	Centigrade.
1°	0°.8	35°	28°.0	69°	55°.2	1°	1°.25	28°	35°.00	55°	68°.75
2	1.6	36	28.8	70	56.0	2	2.50	29	36.25	56	70.00
3	2.4	37	29.6	71	56.8	3	3.75	30	37.50	57	71.25
4	3.2	38	30.4	72	57.6	4	5.00	31	38.75	58	72.50
5	4.0	39	31.2	73	58.4	5	6.25	32	40.00	59	73.75
6	4.8	40	32.0	74	59.2	6	7.50	33	41.25	60	75.00
7	5.6	41	32.8	75	60.0	7	8.75	34	42.50	61	76.25
8	6.4	42	33.6	76	60.8	8	10.00	35	43.75	62	77.50
9	7.2	43	34.4	77	61.6	9	11.25	36	45.00	63	78.75
10	8.0	44	35.2	78	62.4	10	12.50	37	46.25	64	80.00
11	8.8	45	36.0	79	63.2	11	13.75	38	47.50	65	81.25
12	9.6	46	36.8	80	64.0	12	15.00	39	48.75	66	82.50
13	10.4	47	37.6	81	64.8	13	16.25	40	50.00	67	83.75
14	11.2	48	38.4	82	65.6	14	17.50	41	51.25	68	85.00
15	12.0	49	39.2	83	66.4	15	18.75	42	52.50	69	86.25
16	12.8	50	40.0	84	67.2	16	20.00	43	53.75	70	87.50
17	13.6	51	40.8	85	68.0	17	21.25	44	55.00	71	88.75
18	14.4	52	41.6	86	68.8	18	22.50	45	56.25	72	90.00
19	15.2	53	42.4	87	69.6	19	23.75	46	57.50	73	91.25
20	16.0	54	43.2	88	70.4	20	25.00	47	58.75	74	92.50
21	16.8	55	44.0	89	71.2	21	26.25	48	60.00	75	93.75
22	17.6	56	44.8	90	72.0	22	27.50	49	61.25	76	95.00
23	18.4	57	45.6	91	72.8	23	28.75	50	62.50	77	96.25
24	19.2	58	46.4	92	73.6	24	30.00	51	63.75	78	97.50
25	20.0	59	47.2	93	74.4	25	31.25	52	65.00	79	98.75
26	20.8	60	48.0	94	75.2	26	32.50	53	66.25	80	100.00
27	21.6	61	48.8	95	76.0	27	33.75	54	67.50		
28	22.4	62	49.6	96	76.8						
29	23.2	63	50.4	97	77.6						
30	24.0	64	51.2	98	78.4						
31	24.8	65	52.0	99	79.2						
32	25.6	66	52.8	100	80.0						
33	26.4	67	53.6								
34	27.2	68	54.4								

TABLE *for converting Degrees of the Fahrenheit Thermometer to Degrees of Centigrade.*

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
32°	0°	69°	20°.555	106°	41°.111	143°	61°.666	180°	82°.222
33	0.555	70	21.111	107	41.666	144	62.222	181	82.777
34	1.111	71	21.666	108	42.222	145	62.777	182	83.333
35	1.666	72	22.222	109	42.777	146	63.333	183	83.888
36	2.222	73	22.777	110	43.333	147	63.888	184	84.444
37	2.777	74	23.333	111	43.888	148	64.444	185	85.000
38	3.333	75	23.888	112	44.444	149	65.000	186	85.555
39	3.888	76	24.444	113	45.000	150	65.555	187	86.111
40	4.444	77	25.000	114	45.555	151	66.111	188	86.666
41	5.000	78	25.555	115	46.111	152	66.666	189	87.222
42	5.555	79	26.111	116	46.666	153	67.222	190	87.777
43	6.111	80	26.666	117	47.222	154	67.777	191	88.333
44	6.666	81	27.222	118	47.777	155	68.333	192	88.888
45	7.222	82	27.777	119	48.333	156	68.888	193	89.444
46	7.777	83	28.333	120	48.888	157	69.444	194	90.000
47	8.333	84	28.888	121	49.444	158	70.000	195	90.555
48	8.888	85	29.444	122	50.000	159	70.555	196	91.111
49	9.444	86	30.000	123	50.555	160	71.111	197	91.666
50	10.000	87	30.555	124	51.111	161	71.666	198	92.222
51	10.555	88	31.111	125	51.666	162	72.222	199	92.777
52	11.111	89	31.666	126	52.222	163	72.777	200	93.333
53	11.666	90	32.222	127	52.777	164	73.333	201	93.888
54	12.222	91	32.777	128	53.333	165	73.888	202	94.444
55	12.777	92	33.333	129	53.888	166	74.444	203	95.000
56	13.333	93	33.888	130	54.444	167	75.000	204	95.555
57	13.888	94	34.444	131	55.000	168	75.555	205	96.111
58	14.444	95	35.000	132	55.555	169	76.111	206	96.666
59	15.000	96	35.555	133	56.111	170	76.666	207	97.222
60	15.555	97	36.111	134	56.666	171	77.222	208	97.777
61	16.111	98	36.666	135	57.222	172	77.777	209	98.333
62	16.666	99	37.222	136	57.777	173	78.333	210	98.888
63	17.222	100	37.777	137	58.333	174	78.888	211	99.444
64	17.777	101	38.333	138	58.888	175	79.444	212	100.000
65	18.333	102	38.888	139	59.444	176	80.000		
66	18.888	103	39.444	140	60.000	177	80.555		
67	19.444	104	40.000	141	60.555	178	81.111		
68	20.000	105	40.555	142	61.111	179	81.666		

TABLE *for converting Degrees of Centigrade Thermometer to Degrees of Fahrenheit.*

Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.
0°	32°	17°	62°.6	34°	93°.2	51°	123°.8	68°	154°.4	85°	185°.0
1	33.8	18	64.4	35	95.0	52	125.6	69	156.2	86	186.8
2	35.6	19	66.2	36	96.8	53	127.4	70	158.0	87	188.6
3	37.4	20	68.0	37	98.6	54	129.2	71	159.8	88	190.4
4	39.2	21	69.8	38	100.4	55	131.0	72	161.6	89	192.2
5	41.0	22	71.6	39	102.2	56	132.8	73	163.4	90	194.0
6	42.8	23	73.4	40	104.0	57	134.6	74	165.2	91	195.8
7	44.6	24	75.2	41	105.8	58	136.4	75	167.0	92	197.6
8	46.4	25	77.0	42	107.6	59	138.2	76	168.8	93	199.4
9	48.2	26	78.8	43	109.4	60	140.0	77	170.6	94	201.2
10	50.0	27	80.6	44	111.2	61	141.8	78	172.4	95	203.0
11	51.8	28	82.4	45	113.0	62	143.6	79	174.2	96	204.8
12	53.6	29	84.2	46	114.8	63	145.4	80	176.0	97	206.6
13	55.4	30	86.0	47	116.6	64	147.2	81	177.8	98	208.4
14	57.2	31	87.8	48	118.4	65	149.0	82	179.6	99	210.2
15	59.0	32	89.6	49	120.2	66	150.8	83	181.4	100	212.0
16	60.8	33	91.4	50	122.0	67	152.6	84	183.2		

Hydrometer, Alcoholometer, Areometer.

The areometer is an instrument whose construction depends on the philosophical principle that any body floating in a liquid displaces a volume of that liquid equal in weight to its own, from which it appears, on applying this principle to the instrument in question, it will sink deeper in a liquid of little specific gravity, and not so deep in a denser liquid or one of greater specific gravity.

There are two instruments alike in conformation, but differing only in the character of the liquids to which they are applicable, and bearing special names, indicative of the special liquids for the testing of which they are intended: one used for liquids heavier than pure water, as concentrated acids, saline solutions, syrups, must, either natural or artificial, &c., called *acidimeter saccharometer*, &c.; the other, which is employed for ascertaining the density of liquids lighter than water, as wines, spirits, alcohols, ethers, &c., is called *alcoholometer*, &c. A single areometer, with a

stem long enough, might answer for all cases; but the inconvenience inseparable from too long a stem, more than counterbalances its advantages. The areometers in general use, consist of a graduated glass tube, with an elongated bulb, containing a weight at the inferior extremity; they are, however, sometimes made of metal.

It must be observed that the degrees given by the areometer are only true when the liquid under examination is at the same temperature as the instrument when it was graduated.

One other point to be observed, is that the true level which is to be considered, is the ideal extension of the surface of the liquid under examination, and not the point marked on the stem by the summit of the curve caused by the capillarity of the stem of the instrument.

The areometer of Baumé is generally the only one used for liquids heavier than water. We shall speak of it more fully under the subject of syrups, and may dispense with any further notice of it here.

The *densimeter* is designed to replace the areometer of Baumé; it is the only one sanctioned by the adminstration of the assize for use in sugar refineries and distilleries. This instrument, placed in a liquid, indicates its density; that is to say, its weight in kilogrammes for a litre of the liquid.

For example: for a liquid, the density of which will be double that of water, the weight of the litre being two kilogrammes, one kilogramme of this liquid would only occupy the volume of half a litre; consequently, the indication by the densimeter would be 2.

The difference between the indications by the densimeter in saccharine liquids and syrups, will be proportional to the quantity per cent. in sugar or saccharine matter contained in the syrup, and as many kilogrammes of sugar should be counted in the hundred kilogrammes of syrup as there are degrees above 100.

There are a number of alcoholometers; those of Baumé, of Cartier, and of Gay Lussac, are the principal. The last is the simplest, in some respects, and will be more particularly described.

Centesimal Alcoholometer of Gay Lussac.

Gay Lussac, in 1824, invented an instrument resembling the ordinary areometer in form, to which he gave the name *centesimal alcoholometer.* When this instrument is plunged into a spirituous liquid, at the temperature of fifteen degrees, it at once indicates the *strength;* that is, the real volume of pure alcohol which it contains. His scale is divided into 100 parts or degrees, of which each represents a hundredth of anhydrous alcohol. The mark zero (0°) corresponds to pure water, and that for 100° to absolute alcohol. The instrument is graduated at a temperature of 15° in spirits supposed to be of the same temperature; if, for example, the alcoholometer of Gay Lussac sinks to the division 50°, it indicates that the strength of the spirit is fifty hundredths; in other words, that it consists of equal volumes of pure alcohol and water. In a liquor in which it floats at 90°, it will indicate a strength of ninety hundredths. The degrees of the alcoholometer indicating, as they do, the hundredths of alcohol, are called *centesimal degrees.*

Thus, according to the principles on which the centesimal alcoholometer is graduated, the strength of a spirituous liquid is the number of hundredths (in volume) of pure alcohol which this liquid contains at 15° Centigrade; from which it follows, that the real quantity of alcohol contained in a liquor, can always be ascertained readily and immediately, by multiplying the number which expresses the volume of the liquid by the number indicating its strength; which is seen by the greater or less immersion of the instrument in the liquor. Let us suppose, for example, a cask of 345 litres of brandy, the strength of which is 58 centesimal degrees, at the temperature of 15° Centigrade, that is to say, 58 per cent. of pure alcohol.

The following result:

$$\begin{array}{r} 345 \\ 58 \\ \hline 27.60 \\ 172.5 \\ \hline 200.10 \end{array}$$

will indicate that the cask contains 200.10 litres of pure alcohol.

If the spirituous liquor should not be at the temperature of 15° Centigrade, it should be brought to this degree by heating it with the hand, or cooling it by placing the test glass in cold water; but it will be always more convenient in practice, to use the annexed table for ascertaining the actual strength of liquors at any given temperature.

Explanation of the Use of the Table Indicating the Actual Strength of Spirituous Liquors at any Given Temperature.

The centesimal alcoholometer, on which is based the collection of taxes, was graduated, as we have said, at the temperature of 15° Centigrade (12° Reaumer, 59° Fahrenheit). If the experiment be conducted at a higher temperature, the density of the liquid being diminished by expansion, the alcoholometer will sink deeper, and will indicate a greater degree of strength than at the legal temperature of 15°. The opposite will happen if the experiment be tried at a lower degree; it is, therefore, important, in the event that we cannot select or regulate the temperature, that we should be able to ascertain the true alcoholic degree of spirituous liquors to serve as a basis, either for the collection of duties, or to govern commercial transactions.

The following table supplies the means. It consists of two parts. The first indicates what are called degrees of *cold*; that is, those which are below 15°, and the second the degrees of *heat*, or those which are above 15° up to the temperature 30° of the Centigrade thermometer. The first column indicates the degree marked on the centesimal alcoholometer when plunged into a spirituous liquor, the following columns indicate its true degree for the temperature at the head of each column. Thus when the alcoholometer sinks to 49°, and the thermometer plunged into the same liquid indicates a temperature of 8°, we see that the true degree is 51.6. The same degree, if we make the experiment at a temperature of 24° with the same thermometer, would be only 45.6.

The areometer of Cartier being still used in some cities in the south and middle of France, we have thought it best to exhibit its relation to the centesimal alcoholometer, in connection with the tables indicating the true alcoholic strength of liquids.

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF COLD.															
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
1	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.2	1.2	1.1	1.0
2	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.3	2.2	2.1	2.0
3	3.6	3.6	3.6	3.6	3.6	3.5	3.5	3.5	3.5	3.5	3.4	3.4	3.3	3.2	3.1	3.0
4	4.6	4.6	4.6	4.6	4.6	4.5	4.5	4.5	4.5	4.5	4.5	4.4	4.3	4.2	4.1	4.0
	5.6	5.6	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.5	5.5	5.4	5.3	5.2	5.1	5.0
6	6.7	6.9	6.7	6.7	6.7	6.6	6.6	6.6	6.6	6.6	6.5	6.4	6.3	6.2	6.1	6.0
7	7.8	7.8	7.8	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.5	7.4	7.3	7.2	7.1	7.0
8	8.8	8.8	8.8	8.8	8.8	8.7	8.7	8.7	8.7	8.7	8.5	8.4	8.3	8.2	8.1	8.0
9	9.9	9.9	9.9	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.5	9.4	9.3	9.2	9.1	9.0
10	11.0	11.0	11.0	11.0	11.0	10.9	10.9	10.9	10.9	10.9	10.6	10.5	10.4	10.3	10.2	10.0
11	12.2	12.2	12.2	12.2	12.2	12.1	12.1	12.1	12.1	12.1	11.7	11.6	11.5	11.5	11.2	11.0
12	13.4	13.4	13.4	13.3	13.3	13.2	13.1	13.0	13.0	12.9	12.7	12.6	12.5	12.4	12.2	12.0
13	14.7	14.7	14.7	14.6	14.5	14.4	14.3	14.2	14.1	14.0	13.8	13.6	13.5	13.4	13.2	13.0
14	16.1	16.0	16.0	15.9	15.8	15.7	15.6	15.4	15.3	15.1	14.9	14.7	14.6	14.4	14.2	14.0
15	17.5	17.3	17.2	17.1	16.9	16.8	16.7	16.6	16.4	16.2	16.0	15.8	15.6	15.4	15.2	15.0
16	18.9	18.7	18.5	18.3	18.1	18.0	17.8	17.7	17.5	17.3	17.0	16.8	16.6	16.4	16.2	16.0
17	20.3	20.0	19.8	19.6	19.4	19.2	19.0	18.8	18.6	18.4	18.1	17.9	17.6	17.4	17.2	17.0
18	21.6	21.3	21.1	20.8	20.6	20.4	20.2	20.0	19.7	19.5	19.2	19.0	18.7	18.5	18.2	18.0
19	22.9	22.6	22.3	22.0	21.8	21.5	21.3	21.0	20.7	20.5	20.2	20.0	19.7	19.5	19.2	19.0
20	24.2	23.9	23.6	23.3	23.0	22.7	22.4	22.1	21.8	21.6	21.3	21.0	20.7	20.5	20.2	20.0
21	25.6	25.3	24.9	24.6	24.3	24.0	23.6	23.3	23.0	22.7	22.4	22.1	21.8	21.5	21.2	21.0
22	27.0	26.7	26.3	25.9	25.6	25.2	24.9	24.6	24.2	23.9	23.5	23.2	22.9	22.6	22.3	22.0
23	28.4	28.0	27.5	27.1	26.8	26.4	26.0	25.7	25.3	25.0	24.6	24.3	24.0	23.6	23.3	23.0
24	29.7	29.2	28.8	28.4	28.0	27.6	27.2	26.9	26.5	26.1	25.7	25.4	25.1	24.7	24.3	24.0
25	30.9	30.4	30.0	29.6	29.2	28.8	28.4	28.0	27.6	27.2	26.8	26.5	26.1	25.7	25.3	25.0

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF COLD.															
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
26	32.1	31.6	31.2	30.8	30.4	30.0	29.6	29.2	28.8	28.4	27.9	27.6	27.2	26.8	26.4	26.0
27	33.2	32.7	32.3	31.9	31.4	31.0	30.6	30.2	29.8	29.4	29.0	28.6	28.2	27.8	27.4	27.0
28	34.3	33.8	33.3	32.9	32.5	32.1	31.6	31.2	30.8	30.4	30.0	29.6	29.2	28.8	28.4	28.0
29	35.3	34.8	34.4	33.9	33.5	33.1	32.6	32.2	31.8	31.4	31.0	30.6	30.2	29.8	29.4	29.0
30	36.3	35.8	35.4	34.9	34.5	34.1	33.6	33.2	32.8	32.4	32.0	31.6	31.2	30.8	30.4	30.0
31	37.3	36.8	86.4	36.0	35.5	35.1	34.7	34.2	33.8	33.4	33.0	32.6	32.2	31.8	31.4	31.0
32	38.3	37.8	37.4	37.0	36.5	36.1	35.7	35.2	34.8	34.4	34.0	33.6	33.2	32.8	32.4	32.0
33	39.2	38.8	38.4	38.0	37.5	37.1	36.7	36.2	35.8	35.4	35.0	34.6	34.2	33.8	33.4	33.0
34	40.2	39.8	39.4	39.0	38.5	38.1	37.7	37.2	36.8	36.4	36.0	35.6	35.2	34.8	34.4	34.0
35	41.1	40.8	40.4	40.0	39.5	39.1	38.7	38.2	37.8	37.4	37.0	36.6	36.2	35.8	35.4	35.0
36	42.1	41.8	41.4	41.0	40.5	40.1	39.7	39.2	38.8	38.4	38.0	37.6	37.2	36.8	36.4	36.0
37	43.1	42.7	42.3	42.0	41.5	41.1	40.7	40.2	39.8	39.4	39.0	38.6	38.2	37.8	37.4	37.0
38	44.0	43.7	43.3	42.9	42.5	42.1	41.6	41.2	40.8	40.4	40.0	39.6	39.2	38.8	38.4	38.0
39	45.0	44.6	44.2	43.9	43.5	43.1	42.6	42.2	41.8	41.4	41.0	40.6	40.2	39.8	39.4	39.0
40	45.9	45.5	45.1	44.8	44.4	44.0	43.6	43.2	42.8	42.4	42.0	41.6	41.2	40.8	40.4	40.0
41	46.9	46.5	46.1	45.8	45.4	45.0	44.6	44.2	43.8	43.4	43.0	42.6	42.2	41.8	41.4	41.0
42	47.9	47.5	47.1	46.7	46.4	45.9	45.5	45.1	44.8	44.4	44.0	43.6	43.2	42.8	42.4	42.0
43	48.8	48.4	48.1	47.7	47.4	46.9	46.5	46.1	45.8	45.4	45.0	44.6	44.2	43.8	43.4	43.0
44	49.8	49.4	49.0	48.6	48.3	47.9	47.5	47.1	46.8	46.4	46.0	45.6	45.2	44.8	44.4	44.0
45	50.7	50.3	49.9	49.6	49.2	48.8	48.4	48.1	47.7	47.3	46.9	46.6	46.2	45.8	45.4	45.0
46	51.7	51.3	50.9	50.5	50.2	49.8	49.4	49.1	48.7	48.3	47.9	47.6	47.2	46.8	46.4	46.0
47	52.6	52.2	51.8	51.5	51.1	50.7	50.4	50.1	49.7	49.3	48.9	48.6	48.2	47.8	47.4	47.0
48	53 5	53.2	52.8	52.4	52.1	51.7	51.4	51.0	50.6	50.2	49.9	49.5	49.2	48.8	48.4	48.0
49	54.5	54.2	53.8	53.4	53.0	52.7	52.4	52.0	51.6	51.2	50.9	50.5	50.2	49.8	49.4	49.0
50	55.4	55.1	54.7	54.3	54.0	53.6	53.3	52.9	52.6	52.2	51.8	51.5	51.1	50.8	50.4	50.0

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF COLD.															
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
51	56.4	56.0	55.7	55.3	55.0	54.6	54.3	53.9	53.6	53.2	52.8	52.5	52.1	51.8	51.4	51.0
52	57.3	57.0	56.6	56.3	56.0	55.6	55.2	54.9	54.6	54.2	53.8	53.5	53.1	52.7	52.3	52.0
53	58.3	57.9	57.6	57.2	56.9	56.6	56.2	55.9	55.5	55.1	54.8	54.4	54.1	53.7	53.3	53.0
54	59.2	58.9	58.5	58.2	57.9	57.5	57.1	56.8	56.5	56.1	55.8	55.4	55.0	54.7	54.3	54.0
55	60.2	59.9	59.5	59.2	58.9	58.5	58.1	57.8	57.5	57.1	56.8	56.4	56.0	55.7	55.3	55.0
56	61.2	60.9	60.5	60.2	59.8	59.5	59.1	58.8	58.5	58.1	57.8	57.4	57.0	56.7	56.3	56.0
57	62.1	61.8	61.5	61.1	60.8	60.4	60.1	59.8	59.5	59.1	58.8	58.4	58.0	57.7	57.3	57.0
58	63.1	62.8	62.4	62.1	61.7	61.4	61.0	60.7	60.4	60.0	59.7	59.4	59.0	58.7	58.3	58.0
59	64.1	63.8	63.4	63.1	62.7	62.4	62.0	61.7	61.4	61.0	60.7	60.4	60.0	59.7	59.3	59.0
60	65.0	64.7	64.4	64.1	63.7	63.4	63.0	62.7	62.4	62.0	61.7	61.4	61.0	60.7	60.3	60.0
61	66.0	65.7	65.3	65.0	64.7	64.3	64.0	63.7	63.4	63.0	62.7	62.4	62.0	61.7	61.3	61.0
62	67.0	66.7	66.3	66.0	65.7	65.3	65.0	64.7	64.4	64.0	63.7	63.4	63.0	62.7	62.3	62.0
63	68.0	67.7	67.3	67.0	66.6	66.3	66.0	65.7	65.4	65.0	64.7	64.4	64.0	63.7	63.3	63.0
64	68.9	68.6	68.3	68.0	67.6	67.3	67.0	66.7	66.4	66.0	65.7	65.4	65.0	64.7	64.3	64.0
65	69.9	69.6	69.3	68.9	68.6	68.3	68.0	67.6	67.3	67.0	66.7	66.4	66.0	65.7	65.3	65.0
66	70.8	70.5	70.2	69.9	69.5	69.2	68.9	68.6	68.3	67.9	67.6	67.3	67.0	66.7	66.3	66.0
67	71.8	71.5	71.2	70.8	70.5	70.2	69.9	69.6	69.3	68.9	68.6	68.3	68.0	67.7	67.3	67.0
68	72.7	72.4	72.1	71.8	71.5	71.2	70.9	70.6	70.2	69.9	69.6	69.3	69.0	68.7	68.3	68.0
69	73.7	73.4	73.1	72.8	72.5	72.2	71.9	71.5	71.2	70.9	70.6	70.3	70.0	69.6	69.3	69.0
70	74.7	74.3	74.0	73.7	73.4	73.1	72.8	72.5	72.2	71.9	71.6	71.3	71.0	70.6	70.3	70.0
71	75.6	75.3	75.0	74.7	74.4	74.1	73.8	73.5	73.2	72.9	72.6	72.3	72.0	71.6	71.3	71.0
72	76.6	76.3	76.0	75.7	75.3	75.0	74.7	74.4	74.1	73.8	73.5	73.2	72.9	72.6	72.3	72.0
73	77.6	77.3	77.0	76.7	76.3	76.0	75.7	75.4	75.1	74.8	74.5	74.2	73.9	73.6	73.3	73.0
74	78.6	78.3	78.0	77.7	77.3	77.0	76.7	76.4	76.1	75.8	75.5	75.2	74.9	74.6	74.3	74.0
75	79.5	79.2	78.9	78.6	78.3	78.0	77.7	77.4	77.1	76.8	76.5	76.2	75.9	75.6	75.3	75.0

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF COLD.															
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
76	80.5	80.2	79.9	79.6	79.3	79.0	78.7	78.4	78.1	77.8	77.5	77.2	76.9	76.6	76.3	76.0
77	81.5	81 2	80.9	80.6	80.3	80.0	79.7	79.4	79.1	78.8	78.5	78.2	77.9	77.6	77.3	77 0
78	82.4	82.1	81.9	81.6	81.3	81.0	80.7	80.4	80.1	79.8	79.5	79.2	78.9	78.6	78.3	78.0
79	83.3	83.1	82.8	82.5	82.2	81.9	81.6	81.4	81.1	80.8	80.5	80.2	79.9	79.6	79.3	79.0
80	84.3	84.0	83.7	83.5	83.2	82.9	82.6	82.3	82.0	81.7	81.5	81.2	80.9	80.6	80.3	80.0
81	85.2	85.0	84.7	84.4	84.2	83.9	83.6	83.3	83.0	82.7	82.4	82.2	81.9	81.6	81.3	81.0
82	86.2	85.9	85.6	85.4	85.1	84 8	84.5	84.2	84.0	83.7	83.4	83.1	82.9	82.6	82.3	82.0
83	87.1	86.8	86.6	86.3	86.1	85.8	85.5	85.2	85.0	84.7	84.4	84.1	83.9	83.6	83.3	83.0
84	88.0	87.8	87.5	87.3	87.0	86.7	86.5	86.2	85.9	85.7	85.4	85.1	84.8	84.6	84.3	84.0
85	88.9	88.7	88.5	88.2	87.9	87.7	87.4	87.2	86.9	86.6	86.4	86.1	85.8	85.5	85.3	85.0
86	89.9	89.6	89.4	89.2	88.9	88.6	88.4	88.1	87.9	87.6	87.4	87.1	86.8	86.5	86.3	86.0
87	90.8	90.5	90.3	90.1	89.8	89.6	89.3	89.1	88.8	88.6	88.3	88.0	87.8	87.5	87.3	87.0
88	91.7	91.5	91.2	91.0	90.8	90.5	90.2	90.0	89.8	89.5	89.3	89.0	88.7	88.5	88.2	88.0
89	92.6	92.4	92.2	91.9	91.7	91.5	91.2	91.0	90.7	90.5	90.2	90.0	89.7	89.5	89.2	89.0
90	93.6	93.3	93.1	92.9	92.7	92.4	92.2	91.9	91.7	91.5	91.2	91.0	90.7	90.5	90.2	90.0
91	94.5	94.3	94.0	93.8	93.6	93.4	93.1	92.9	92.7	92.5	92.2	92.0	91.7	91.5	91.2	91.0
92	95.3	95.1	94.9	94.7	94.5	94.3	94.1	93.9	93.6	93.4	93.2	92.9	92.7	92.5	92.2	92.0
93	96.2	96.0	95.8	95.6	95.4	95.2	95.0	94.8	94.6	94.4	94.2	93.9	93.7	93.5	93.2	93.0
94	97.1	96.9	96.7	96.5	96.3	96.1	95.9	95.7	95.5	95.3	95.1	94.9	94.7	94.4	94.2	94.0
95	98.0	97.8	97.6	97.4	97.2	97.0	96.8	96.6	96.4	96.2	96.0	95.8	95.6	95.4	95.2	95.0
96	98.8	98.6	98.5	98.3	98.1	97.9	97.8	97.6	97.4	97.2	97.0	96.8	96.6	96.4	96.2	96.0
97	99.7	99.5	99.3	99.2	99 0	98.8	98.7	98.5	98.3	98.1	98.0	97.8	97.6	97.4	97.2	97.0
98	100.0	100.0	100.0	100.0	99.9	99.7	99.6	99.4	99.2	99.1	98.9	98.7	98.5	98.4	98.2	98.0
99	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.7	99.5	99.3	99.2	99.0
100	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	100.0

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF HEAT.														
	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.1	1.0	0.8	0.7	0.5	0.3	0.1	0.0
3	2.9	2.8	2.7	2.6	2.4	2.3	2.2	2.1	1.9	1.7	1.6	1.5	1.3	1.1	0.9
4	3.9	3.8	3.7	3.6	3.4	3.3	3.2	3.1	2.9	2.7	2.6	2.4	2.2	2.0	1.9
5	4.9	4.8	4.7	4.5	4.4	4.3	4.1	4.0	3.8	3.6	3.5	3.3	3.1	2.9	2.8
6	5.9	5.8	5.7	5.5	5.4	5.2	5.1	4.9	4.8	4.6	4.4	4.3	4.1	3.9	3.7
7	6.9	6.8	6.7	6.5	6.4	6.2	6.1	5.9	5.8	5.5	5.4	5.2	5.0	4.8	4.6
8	7.9	7.8	7.7	7.5	7.3	7.1	7.0	6.8	6.7	6.5	6.3	6.1	5.9	5.7	5.5
9	8.9	8.8	8.7	8.5	8.3	8.1	7.9	7.8	7.6	7.4	7.2	7.0	6.8	6.6	6.4
10	9.9	9.8	9.7	9.5	9.3	9.1	8.9	8.7	8.5	8.3	8.1	7.9	7.7	7.5	7.3
11	10.9	10.8	10.7	10.5	10.3	10.1	9.9	9.7	9.5	9.3	9.0	8.8	8.6	8.4	8.1
12	11.9	11.7	11.6	11.4	11.2	11.0	10 8	10.6	10.4	10.2	9.9	9.7	9.5	9.2	9.0
13	12.9	12.7	12.5	12.4	12.2	11.9	11.7	11.5	11.3	11.1	10.8	10.6	10.3	10.1	9.8
14	13.9	13.7	13.5	13.3	13.1	12.8	12.6	12.4	12.2	12.0	11.7	11.5	11.2	11.0	10.7
15	14.9	14.7	14.5	14.3	14.0	13.7	13.5	13.3	13.1	12.8	12.6	12.3	12.0	11.8	11.5
16	15.9	15.6	15.4	15.2	14.9	14.6	14.4	14.1	13.9	13.6	13.4	13.1	12.8	12.6	12.3
17	16.9	16.6	16.3	16.1	15.8	15.5	15.3	15.0	14.8	14.5	14.2	14.0	13.7	13.4	13.1
18	17.8	17.5	17.3	17.0	16.7	16.4	16.2	15.9	15.7	15.4	15.1	14.8	14.5	14.2	13.9
19	18.7	18.4	18.2	17.9	17.6	17.3	17.0	16.7	16.5	16.2	15.9	15.6	15.3	15.0	14.7
20	19.7	19.4	19.1	18.8	18.5	18.2	17.9	17.6	17.4	17.1	16.7	16.5	16.1	15.8	15.5
21	20.7	20.4	20.1	19.8	19.5	19.1	18.8	18.5	18.3	18.0	17.7	17.4	17.0	16.7	16.4
22	21.7	21.4	21.1	20.8	20.5	20.1	19.8	19.5	19.2	18.9	18.6	18.3	18.0	17.6	17.3
23	22.7	22.4	22.0	21.7	21.4	21.1	20.7	20.4	20.1	19.8	19.5	19.2	18.9	18.5	18.2
24	23 7	23.4	23.0	22.7	22.4	22.1	21.7	21.4	21.1	20.7	20.4	20.1	19.7	19.4	19.1
25	24.7	24.4	24.0	23.6	23.3	23.0	22.6	22.3	21.9	21.6	21.3	20.9	20.6	20.3	19.9

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF HEAT.														
	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
26	25.7	25.4	25.0	24.6	24.3	23.9	23.6	23.2	22.8	22.5	22.2	21.8	21.5	21.1	20.8
27	26.6	26.3	25.9	25.5	25.2	24.8	24.4	24.1	23.7	23.3	23.0	22.7	22.3	21.9	21.6
28	27.6	27.3	26.9	26.5	26.1	25.7	25.3	25.0	24.6	24.3	23.9	23.6	23.2	22.8	22.5
29	28.6	28.2	27.8	27.4	27.1	26.7	26.3	25.9	25.5	25.2	24.8	24.4	24.0	23.7	23.3
30	29.6	29.2	28.8	28.4	28.0	27.6	27.2	26.8	26.4	26.1	25.7	25.3	24.9	24.5	24.2
31	30.6	30.2	29.8	29.4	29.0	28.6	28.2	27.8	27.4	27.0	26.6	26.2	25.8	25.4	25.1
32	31.6	31.2	30.8	30.4	30.0	29.6	29.2	28.8	28.4	28.0	27.6	27.2	26.8	26.4	26.0
33	32.5	32 1	31.7	31.3	30.9	30.5	30.1	29.7	29.3	28.9	28.5	28.1	27.7	27.3	26.9
34	33.5	33.1	32.7	32.3	31.9	31.5	31.1	30.7	30.3	29.9	29.5	29.1	28.7	28.3	27.9
35	34.5	34.1	33.7	33.3	32.9	32.5	32.1	31.7	31.3	30.9	30.5	30.1	29.7	29.3	28.9
36	35.5	35.1	34.7	34.3	33.9	33.5	33.1	32.7	32.3	31.9	31.5	31.1	30.7	30.3	29.9
37	36.5	36.1	35.7	35.3	34.9	34.5	34.1	33.7	33.3	32.9	32.5	32.1	31.7	31.3	30.9
38	37.5	37.1	36.7	36.3	35.9	35.5	35.1	34.7	34.3	33.9	33.5	33.1	32.7	32.3	31.9
39	38.5	38.1	37.7	37.3	36.9	36.5	36.1	35.7	35.3	34.9	34.5	34.1	33.7	33.3	32.9
40	39.5	39.1	38.7	38.3	37.9	37.5	37.1	36.7	36.3	35.9	35.5	35.1	34.7	34.3	33.9
41	40.6	40.2	39.8	39.4	39.0	38.6	38.2	37.8	37.4	37.0	36.5	36.1	35.7	35.3	34.9
42	41.6	41.2	40.8	40.4	40.0	39.6	39.2	38.8	38.4	38.0	37.6	37.2	36.8	36.3	35.9
43	42.6	42.2	41.8	41.4	41.0	40.6	40.2	39.8	39.4	39.0	38.6	38.2	37.8	37.4	37.0
44	43.6	43.2	42.8	42.5	42.1	41.7	41.3	40.9	40.5	40.1	39.7	39.3	38.9	38.5	38.1
45	44.6	44.2	43.8	43.5	43.1	42.7	42.3	41.9	41.5	41.1	40.7	40.3	39.9	39.5	39.1
46	45.6	45.2	44.9	44.5	44.1	43.7	43.3	42.9	42.5	42.2	41.8	41.4	41.0	40.6	40.2
47	46.6	46.2	45.9	45.5	45.1	44.8	44.3	43.9	43.6	43.2	42.8	42.4	42.0	41.6	41.2
48	47.6	47.2	46.9	46.5	46.1	45.8	45.3	44.9	44.6	44.2	43.8	43.4	43.0	42.6	42.3
49	48.6	48.3	47.9	47.5	47.2	46.8	46.4	46.0	45.6	45.2	44.9	44.5	44.1	43.7	43.3
50	49.6	49.3	48.9	48.5	48.2	47.8	47.4	47.0	46.6	46 3	45.9	45.5	45.1	44.7	44.3

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF HEAT.														
	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
51	50.6	50.3	49.9	49.5	49.2	48.8	48.4	48.0	47.6	47.3	46.9	46.5	46.1	45.7	45.4
52	51.6	51.3	50.9	50.6	50.2	49.8	49.4	49.1	48.7	48.3	47.9	47.6	47.2	46.8	46.4
53	52.6	52.3	51.9	51.6	51.2	50.8	40.4	50.1	49.7	49.3	49.0	48.6	48.2	47.8	47.5
54	53.6	53.3	52 9	52 6	52.2	51.8	51.4	51.1	50.7	50.3	50.0	49.6	49.2	48.9	48.5
55	54.6	54.3	53.9	53.6	53.2	52.9	52 5	52.1	51.8	51.4	51.0	50.7	50.3	49.9	49.6
56	55.6	55.3	54.9	54.6	54.2	53.9	53.5	53.1	52.8	52.4	52.0	51.7	51.3	51.0	50.6
57	56.6	56.3	55.9	55.6	55.2	54.9	54 5	54.1	53.8	53.4	53.0	52.7	52.3	52.0	51.6
58	57.6	57.3	56.9	56.6	56.2	55.9	55.5	55.1	54.8	54.4	54.0	53.7	53.3	53.0	52.6
59	58.6	58.3	57.9	57.6	57.2	56.9	56.5	56.1	55.8	55.5	55.1	54.8	54.4	54 0	53.6
60	59.6	59.3	58.9	58.6	58.2	57.9	57.5	57.1	56.8	56.5	56.1	55.8	55.4	55.0	54.7
61	60.6	60.3	59.9	59.6	59.2	58.9	58 5	58.1	57.8	57.5	57.1	56.8	56.4	56.0	55.7
62	61.7	61.3	61.0	60.6	60.3	59.9	59.5	59.2	58.9	58.5	58.1	57.8	57.5	57.1	56.7
63	62.7	62.3	62.0	61.6	61.3	61.0	60.6	60.2	59.9	59.5	59.2	58.8	58.5	58.1	57.8
64	63.7	63.3	63.0	62.7	62.3	62.0	61.6	61.3	61.0	60.6	60.2	59.9	59.5	59.2	58.8
65	64.7	64.3	64.0	63.7	63.3	63.0	62.7	62.3	62.0	61.6	61.3	60.9	60.6	60.2	59.9
66	65.7	65.3	65.0	64.7	64.3	64.0	63.7	63.3	63.0	62.6	62.3	61.9	61.6	61.2	60.9
67	66.7	66.3	66.0	65.7	65.3	65.0	64.7	64.3	64.0	63.7	63.3	63.0	62.6	62.3	61.9
68	67.7	67.3	67.0	66.7	66.4	66.0	65.7	65.4	65.0	64.7	64.3	64.0	63.7	63.3	63.0
69	68.7	68.3	68.0	67.7	67.4	67.0	66.7	66.4	66.0	65.7	65.3	65.0	64.7	64.3	64.0
70	69.7	69.3	69.0	68.7	68.4	68.1	67.8	67.4	67.1	66.7	66.4	66.0	65.7	65.4	65.0
71	70.7	70.3	70.0	69.7	69.4	69.1	68.8	68.4	68.1	67.8	67.4	67.1	66.8	66.4	66.1
72	71.7	71.3	71.0	70.7	70 4	70.1	69.8	69.4	69.1	68.8	68.4	68.1	67.8	67.4	67.1
73	72.7	72.3	72.0	71.7	71.4	71.1	70.8	70.5	70.1	69.8	69.5	69.2	68.8	68.5	68.2
74	73.7	73.3	73.0	72.7	72.4	72.1	71.8	71.5	71.2	70.8	70.5	70.2	69.9	69.5	69.2
75	74.7	74.3	74.0	73.7	73.4	73.1	72.8	72.5	72.2	71.8	71.5	71.2	70.9	70.6	70.3

TABLE *indicating the Actual Strength of Spirituous Liquors.*

Centesimal degrees.	DEGREES OF HEAT. 16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
76	75.7	75.4	75.1	74.7	74.4	74.1	73.8	73.5	73.2	72.8	72.5	72.2	71.9	71.6	71.3
77	76.7	76.4	76.1	75.8	75.5	75.2	74.8	74.5	74.2	73.9	73.6	73.3	73.0	72.6	72.3
78	77.7	77.4	77.1	76.8	76.5	76.2	75.9	75.5	75.2	74.9	74.6	74.3	74.0	73.7	73.3
79	78.7	78.4	78.1	77.8	77.5	77.2	76.9	76.6	76.3	76.0	75.6	75.3	75.0	74.7	74.4
80	79.7	79.4	79.1	78.8	78.5	78.2	77.9	77.6	77.3	77.0	76.7	76.3	76.0	75.7	75.4
81	80.7	80.4	80.1	79.8	79.5	79.2	78.9	78.6	78.3	78.0	77.7	77.4	77.1	76.7	76.4
82	81.7	81.4	81.1	80.8	80.5	80.2	79.9	79.6	79.3	79.0	78.7	78.4	78.1	77.8	77.5
83	82.7	82.4	82.1	81.9	81.6	81.3	81.0	80.7	80.4	80.1	79.8	79.5	79.2	78.9	78.6
84	83.7	83.4	83.1	82.9	82.6	82.3	82.0	81.7	81.4	81.1	80.8	80.5	80.2	79.9	79.6
85	84.7	84.4	84.1	83.9	83.6	83.3	83.0	82.7	82.4	82.2	81.8	81.5	81.2	80.9	80.6
86	85.7	85.4	85.2	84.9	84.6	84.3	84.0	83.8	83.5	83.2	82.9	82.6	82.3	82.0	81.7
87	86.7	86.4	86.2	85.9	85.6	85.3	85.0	84.8	84.5	84.2	83.9	83.6	83.3	83.0	82.7
88	87.7	87.4	87.2	86.9	86.6	86.4	86.1	85.8	85.5	85.2	84.9	84.7	84.4	84.1	83.8
89	88.7	88.4	88.2	87.9	87.7	87.4	87.1	86.8	86.5	86.3	86.0	85.7	85.4	85.1	84.9
90	89.7	89.5	89.2	88.9	88.7	88.4	88.2	87.9	87.6	87.4	87.1	86.8	86.5	86.2	86.0
91	90.8	90.5	90.2	90.0	89.7	89.5	89.2	89.0	88.7	88.4	88.2	87.9	87.6	87.3	87.1
92	91.8	91.5	91.3	91.1	90.8	90.5	90.2	90.0	89.7	89.5	89.2	89.0	88.7	88.4	88.2
93	92.8	92.6	92.3	92.1	91.8	91.6	91.3	91.1	90.8	90.6	90.3	90.1	89.8	89.5	89.3
94	93.8	93.6	93.3	93.1	92.9	92.6	92.4	92.1	91.9	91.6	91.4	91.1	90.9	90.6	90.4
95	94.8	94.6	94.3	94.1	93.9	93.7	93.4	93.2	93.0	92.7	92.5	92.2	92.0	91.7	91.5
96	95.8	95.6	95.4	95.2	95.0	94.7	94.5	94.3	94.1	93.8	93.6	93.4	93.1	92.9	92.7
97	96.8	96.6	96.4	96.2	96.0	95.8	95.6	95.4	95.2	94.9	94.7	94.5	94.3	94.1	93.8
98	97.8	97.6	97.4	97.3	97.1	96.9	96.7	96.5	96.2	96.0	95.8	95.6	95.4	95.2	95.0
99	98.8	98.7	98.5	98.3	98.1	97.9	97.7	97.5	97.3	97.1	97.9	96.7	96.5	96.3	96.1
100	99.8	99.7	99.5	99.3	99.1	99.0	98.8	98.6	98.4	98.2	98.1	97.9	97.7	97.5	97.3

TABLE *by which to find the value of degrees on the Alcoholometer of Cartier in terms of the centesimal Alcoholometer.*

Centesimal degrees.	Degrees of Cartier.	Centesimal degrees.	Degrees of Cartier.	Centesimal degrees.	Degrees of Cartier.	Centesimal degrees.	Degrees of Cartier.	Centesimal degrees.	Degrees of Cartier.
0	10″	21	13⅜	42	17⅛	63	23½	84	32¾
1	10¼	22	13½	43	17⅜	64	23⅞	85	33¼
2	10⅜	23	13⅝	44	17⅝	65	24¼	86	33⅞
3	10⅝	24	13¾	45	17⅞	66	24⅝	87	34⅜
4	10¾	25	13⅞	46	18⅛	67	25″	88	35″
5	10⅞	26	14⅛	47	18⅜	68	25⅜	89	35⅝
6	11⅛	27	14¼	48	18⅝	69	25¾	90	36¼
7	11¼	28	14⅜	49	18⅞	70	26¼	91	36⅞
8	11½	29	14½	50	19¼	71	26⅝	92	37½
9	11⅝	30	14⅝	51	19½	72	27″	93	38¼
10	11¾	31	14⅞	52	19¾	73	27½	94	38⅞
11	11⅞	32	15″	53	20⅛	74	27⅞	95	39⅝
12	12⅛	33	15⅛	54	20⅜	75	28⅜	96	40½
13	12¼	34	15⅜	55	20¾	76	28⅞	97	41¼
14	12⅜	35	15⅝	56	21″	77	29¼	98	42¼
15	12½	36	15¾	57	21⅜	78	29¾	99	43⅛
16	12⅝	37	16″	58	21¾	79	30¼	100	44⅛
17	12¾	38	16⅛	59	22″	80	30¾		
18	12⅞	39	16⅜	60	22⅜	81	31¼		
19	13″	40	16⅝	61	22¾	82	31¾		
20	13¼	41	16⅞	62	23⅛	83	32¼		

[As it may be interesting to some, the translator has taken the liberty of adding the following tables from Fownes' Chemistry, which institute a comparison between the specific gravity of different liquids both heavier and lighter than water, and a third which indicates the true alcoholic strength of a spirituous liquor as indicated by its specific gravity.]

Comparison of the Degrees of Baumé's Hydrometer with the real Specific Gravities.

1. For liquids heavier than water.

Degrees	Specific gravity.	Degrees	Specific gravity.	Degrees	Specific gravity.	Degrees	Specific gravity.	Degrees	Specific gravity.
0	1.000	16	1.118	32	1.267	48	1.462	64	1.727
1	1.007	17	1.126	33	1.277	49	1.476	65	1.747
2	1.013	18	1.134	34	1.288	50	1.490	66	1.767
3	1.020	19	1.143	35	1.299	51	1.495	67	1.788
4	1.027	20	1.152	36	1.310	52	1.520	68	1.809
5	1.034	21	1.160	37	1.321	53	1.535	69	1.831
6	1.041	22	1.169	38	1.333	54	1.551	70	1.854
7	1.048	23	1.178	39	1.345	55	1.567	71	1.877
8	1.056	24	1.188	40	1.357	56	1.583	72	1.900
9	1.063	25	1.197	41	1.369	57	1.600	73	1.924
10	1.070	26	1.206	42	1.381	58	1.617	74	1.949
11	1.078	27	1.216	43	1.395	59	1.634	75	1.974
12	1.085	28	1.225	44	1.407	60	1.652	76	2.000
13	1.094	29	1.235	45	1.420	61	1.670		
14	1.101	30	1.245	46	1.434	62	1.689		
15	1.109	31	1.256	47	1.448	63	1.708		

2. Baumé's Hydrometer for liquids lighter than water.

Degrees	Specific gravity.	Degrees	Specific gravity.	Degrees	Specific gravity.	Degrees	Specific gravity.	Degrees	Specific gravity.
10	1.000	21	0.930	32	0.869	43	0.816	54	0.768
11	0.993	22	0.924	33	0.864	44	0.811	55	0.764
12	0.986	23	0.918	34	0.859	45	0.807	56	0.760
13	0.980	24	0.913	35	0.854	46	0.802	57	0.757
14	0.973	25	0.907	36	0.849	47	0.798	58	0.753
15	0.967	26	0.901	37	0.844	48	0.794	59	0.749
16	0.960	27	0.896	38	0.839	49	0.789	60	0.745
17	0.954	28	0.890	39	0.834	50	0.785		
18	0.948	29	0.885	40	0.830	51	0.781		
19	0.942	30	0.880	41	0.825	52	0.777		
20	0.936	31	0.874	42	0.820	53	0.773		

These two tables are on the authority of M. Francœur; they are taken from the *Handwörterbuch der Chemie* of Liebig and Poggendorf. Baumé's hydrometer is very commonly used on the Continent, especially for liquids heavier than water. For lighter liquids the hydrometer of Cartier is often employed in France. Cartier's degrees differ but little from those of Baumé.

In the United Kingdom, Twaddell's hydrometer is a good deal used for dense liquids. This instrument is so graduated that the real sp. gr. can be deduced by an extremely simple method from the degree of the hydrometer, namely, by multiplying the latter by 5 and adding 1000; the sum is the sp. gr., water being 1000. Thus 10° Twaddell indicates a sp. gr. of 1050, or 1.05; 90° Twaddell, 1450, or 1.45.—*Fownes' Chemistry.*

TABLE *of the proportion by weight of absolute or real Alcohol in 100 parts of spirits of different specific gravities.* (*Fownes.*)

Sp. gr. at 60° (15°.5 C.)	Percent. of real alcohol.	Sp. gr. at 60° (15°.5 C.)	Percent. of real alcohol.	Sp. gr. at 60° (15°.5 C.)	Percent. of real alcohol.	Sp. gr. at 60° (15°.5 C.)	Percent. of real alcohol.
0.9991	0.5	0.9638	26	0.9135	52	0.8533	78
0.9981	1	0.9623	27	0.9113	53	0.8508	79
0.9965	2	0.9609	28	0.9090	54	0.8483	80
0.9947	3	0.9593	29	0.9069	55	0.8459	81
0.9930	4	0.9578	30	0.9047	56	0.8434	82
0.9914	5	0.9560	31	0.9025	57	0.8408	83
0.9898	6	0.9544	32	0.9001	58	0.8382	84
0.9884	7	0.9528	33	0.8979	59	0.8357	85
0.9869	8	0.9511	34	0.8956	60	0.8331	86
0.9855	9	0.9490	35	0.8932	61	0.8305	87
0.9841	10	0.9470	36	0.8908	62	0.8279	88
0.9828	11	0.9452	37	0.8886	63	0.8254	89
0.9815	12	0.9434	38	0.8863	64	0.8228	90
0.9802	13	0.9416	39	0.8840	65	0.8199	91
0.9789	14	0.9396	40	0.8816	66	0.8172	92
0.9778	15	0.9376	41	0.8793	67	0.8145	93
0.9766	16	0.9356	42	0.8769	68	0.8118	94
0.9753	17	0.9335	43	0.8745	69	0.8089	95
0.9741	18	0.9314	44	0.8721	70	0.8061	96
0.9728	19	0.9292	45	0.8696	71	0.8031	97
0.9716	20	0.9270	46	0.8672	72	0.8001	98
0.9704	21	0.9249	47	0.8649	73	0.7969	99
0.9691	22	0.9228	48	0.8625	74	0.7938	100
0.9678	23	0.9206	49	0.8603	75		
0.9665	24	0.9184	50	0.8581	76		
0.9652	25	0.9160	51	0.8557	77		

Alcoholometric Scale of M. Strope.

M. Stropé, an optician at Orleans, has invented a very convenient and portable little instrument, which is intended for correcting the apparent degrees indicated by the alcoholometer when the temperature is above or below 15 degrees Centigrade. This instrument, which M. Stropé has called the *alcoholometric scale*, fully replaces the table which was formerly used to indicate the alcoholic strength of liquids. The alcoholometric scale consists of a wooden rod, with a sliding scale, on which the degrees of spirituosity are placed on the two sides right and left, and the degrees of temperature are marked on the sliding scale. When it is desired to ascertain the strength of any spirits, it is only necessary to slide the scale so as to bring the degree indicating the tempera-

ture opposite the alcoholic degree, as obtained by the hydrometer, and at once read off the true strength of the liquor.

Let us suppose a brandy the apparent strength of which by the alcoholometer is 48 degrees, at a temperature of five degrees above zero: what is its real strength? The sliding scale is moved so that the fifth degree shall correspond with the 48th division of the fixed scale, and on seeking out the 15th degree, as fixed by the law, we shall see that the real strength of the brandy is 51½ degrees. If, on the contrary, the temperature be at 20 degrees, it will be necessary to lower the scale until the 20th degree corresponds to the 48th division, and on again seeking the 15th degree, the scale indicates the real strength to be 46 degrees.

Experimental Stills.

Areometers only indicate accurately the alcoholic strength of liquids submitted to them, when these liquids contain alcohol and water only; because, in all other cases, the substances dissolved in fermented or other liquors affect their density.

The best method of ascertaining the proportion of alcohol contained in a wine, or other spirituous liquor, is to distil a portion of it, note the volume of weak alcohol obtained, find its degree by the alcoholometer, and then calculate the quantity of absolute alcohol which it represents. Descrozilles invented a small still for this assay, which Gay Lussac, and, more recently, M. Duval, have improved.

Assay Still of Gay Lussac.

This apparatus, Fig. 8, Pl. VI., consists of a small copper still *A*, with a cap *B*, having on one side, at its upper part, an opening *C* which communicates with the tube *D*, which is bent into a spiral, and fixed in the copper refrigerator *E*.

To this still are added two graduated proof glasses. The larger *F* has 300 divisions, which represent 150 millilitres. The second *G* is also divided into millilitres,

and has 180 divisions, of which 100 represent 50 millilitres.

When this still is to be used, the wine is first poured into the larger proof glass up to the division 300. This is introduced into the still, the refrigerator attached, and the still set in an iron cylinder perforated at the top, which fills the place of a furnace; the whole is heated by a spirit lamp *J*.

The small proof glass is placed under the refrigerator to collect the alcoholic product. During the distillation care must be taken to keep the water in the refrigerator cold, and continually to sprinkle the cloth which surrounds the tube of the cap. The distillation is arrested when precisely one-third of the wine used has been collected in the proof glass; that is to say, when the liquid has risen to division 100. The alcoholic richness of this product is then ascertained by the centesimal alcoholometer of Gay Lussac, and, on dividing the number which represents it, by three, we find the alcoholic strength of the wine employed. Let us suppose, for example, that, by the process just described, we have obtained 100 parts of alcohol at 24.5 of the centesimal alcoholometer at the temperature of 15°, we shall conclude that the alcoholic richness of the wine is—

$$\frac{24.50}{3} = 8.166$$

That is to say, that it contains 8.166 parts of absolute or perfectly pure alcohol.

Since this method of examination immediately determines the quantity of absolute alcohol contained in a given sample of wine, it will be easy to ascertain, what will be the contents of a spirit of any strength whatever.

Assay Still of M. J. Salleron.

This new alcoholometer has been adopted by the administration of the assize and of the octroi, at Paris, for determining the tax on liquors.

This apparatus, constructed after the manner of a still, is intended to measure the alcoholic strength of

spirituous liquors, whatever be their nature or the quantity of foreign substances they may contain in solution. It should be used when the alcoholometer of Gay Lussac is in default; that is to say, when examining the standard of wines, saccharine liquors, beer, cider, varnish, &c.; in a word, all liquors, into the composition of which salts, sugar, gums, and coloring substances enter, and which modify or falsify the indications of the ordinary alcoholometer.

The use of the still consists in separating from the liquid all the foreign substances it may contain, by isolating a mixture of water and alcohol, susceptible of being tested by the alcoholometer.

The accuracy, simplicity, and small volume of this instrument render it exceedingly convenient for practical use.

This apparatus, which consists of the following pieces, is packed in a small box. See Fig. 9, Pl. VI.

1. A spirit lamp *A*.

2. A glass globe *B*, which answers to the boiler of the still.

3. Coil contained in the refrigerator *C*, which is supported by three copper rods.

The coil is connected with the boiler by means of an India-rubber tube *D*, terminated by the stopper *E*, which fits the neck of the globe *B*.

4. Proof jar *F*, on which are marked three divisions. One, *a*, for measuring the wine intended for distillation; the two others, marked ½ and ⅓, are for measuring the liquid collected under the coil.

5. An areometer *G*, the divisions of which correspond to those of the alcoholometer of Gay Lussac.

6. A small thermometer *H*.

7. A small glass tube *J*, which is used as a pipette.

The instrument is used as follows: viz. The globe *B* is placed over the lamp *A*, the liquid under examination is measured in the proof glass *F*, by the assistance of the pipette *J*, the surface is adjusted accurately to the mark *a*.

The contents of the proof glass are poured into the globe, the stopper E firmly fixed in its place, and the refrigerator C filled with cold water, to put the apparatus in operation. It only remains to place the proof glass under the worm and light the lamp.

The wine soon begins to boil, the vapor enters the coil where it condenses and flows into the proof glass.

The first portion of the liquid collected is highly concentrated alcohol, that following is less concentrated, and the proportion of alcohol gradually diminishes, until at last only pure water flows from the coil. The operation may then be suspended and the lamp extinguished. But how is it to be known that all of the alcohol has been distilled and that there is no more in the globe? The means are easy enough. Where an ordinary wine is tested it is certain beforehand that its alcohol does not exceed 13 or 15 per cent.; if, then, one-third of the liquid poured into the globe, that is, 33 per cent. of its contents, be drawn off, we may be assured that not only all of the alcohol, but an equal volume of water, has been distilled off and collected in the proof glass; if the liquid in question is highly spirituous as Madeira wine for example, or a sweet liquor which may contain 20 or 25 per cent. of alcohol, it is evident that if only one-third of its volume is drawn off there will be great danger of not obtaining all the alcohol which it contains, and of leaving a portion of it still in the globe. It is therefore necessary to extend the distillation so as to draw off one-half instead of one-third.

In conclusion, common wines (*vins ordinaires*), beer, cider, and all liquors the alcoholic strength of which does not exceed 12 or 15 per cent. should be distilled to one-third. Heady wines, like those of Cette, Madeira, etc., sweet liquors, and in fine, all liquors in which the alcohol varies from 15 to 25 per cent. should be distilled to one-half. It is hardly necessary to say that all liquors, the strength of which is not known approximatively, should be distilled to one-half, in order thereby to avoid all chance of error.

It sometimes happens in distilling a liquor in which the alcoholic fermentation was incomplete, that so great a quantity of foam rises in the globe *B* that a portion of the liquor contained in it passed over unchanged with the distillate. This inconvenience is avoided, or prevented by pouring two or three drops of oil into the globe at the beginning of the operation.

When we have collected in the proof glass enough of the liquor to be assured that we have all the alcohol contained in the wine, the lamp is extinguished and water is poured into the proof glass until it is filled exactly to the level of the mark *a*. In order to perform this operation with ease and precision, we make use of the pipette *J*, which lets the water fall drop by drop. The mixture is well shaken and the alcoholometer and thermometer are simultaneously plunged into it (the groove in the side of the proof glass is intended to receive the thermometer without its interfering with the motion of the alcoholometer).

It is well to moisten the stem of the alcoholometer slightly in order that it may float freely in the liquid. This may be accomplished with the greatest ease by passing the stem between the lips.

The indications of the two instruments are noted and the real strength of the liquid is sought for in the table accompanying the instrument.

In the absence of this table, that which we have given on page 256 and following (explained on page 254) will answer the purpose. The result is exactly the same.

Example.—The alcoholometer indicates 10 degrees and the thermometer 29 degrees. We find by the table that the liquor only weighs 7.5.

And another example.—The alcoholometer marks 18 degrees and the thermometer 11 degrees. We find by the degrees designated that the liquor weighs 19 degrees.

The alcoholometer which accompanies the Salleron still is only graduated for 25 or 30 degrees; it might be supposed that it could be used only for measuring such liquors as do not exceed an alcoholic richness of 25

or 30 per cent., but this is an error. If the precaution is taken to dilute the spirit under examination with a known proportion of water, the most highly spirituous liquors may be operated on. In fact, if we measure the liquor in the proof glass to the mark ½ or ⅓, and then fill to the mark *a* with pure water, the strength of the liquor will have been diminished one-half or two-thirds. The indications of the alcoholometer multiplied by two or three will then give the actual strength.

CHAPTER XI.

REDUCTION OF SPIRITUOUS LIQUORS. IMPROVING. INCREASING THE STRENGTH OR RAISING THE PROOF.

Reduction.

THE weakening of a spirituous liquor by mixing it with water or another spirit of less strength is called in the trade *reduction* or *watering*.

We indicate in a table of reduction which is appended, the number of litres and decilitres of water that it is necessary to add to a hectolitre of *spirit* or brandy of any known degree to dilute it, that is, to transform it into another spirituous liquor, also of a known degree, but weaker.

Throughout this table we suppose that the two liquids (water and alcohol) have the temperature of 15°. If the spirit is not at this temperature, the strength should be estimated at this degree by means of the table of true alcoholic strength given above. As the rate of expansion for water between 0° and 30° is much less than that of alcohol, it will not materially affect the result if no account is taken of its temperature.

The first column of the table consists of the number which indicates the degree of the spirit to be reduced. The second column commencing at 38°, and always increasing as we descend, by unity, indicates the degree

to which the spirit is to be reduced from the degree as shown in the first column.

The third column indicates the number of litres of water that must be added to the hectolitre of spirit or brandy whose degree is indicated in the first column, to reduce it to the degree as given in the second column.

When it is desired, for example, to reduce 100 litres of spirit at 90° to make a spirit at 49°, we seek in the column headed *degree to be reduced* for the number 90, look down the next column for the number 49, and we find opposite to it in the third column the number 88 litres and 6 decilitres, which indicates the quantity of water to be added; that is to say, with 100 litres of spirit at 90°, we ought to produce 188.6 litres of spirit at 49°, if the contraction which takes place in the mixture did not cause a loss of about 4 per cent.

It is now easy to find the volume of water which it is necessary to add to any given quantity of spirit of a known strength to reduce it to an inferior degree, it being sufficient to search in the table for the quantity of water necessary to dilute 100 litres of this spirit, and multiply the number indicating this volume by that of the spirit and divide the product by 100.

Example.—It is required to convert a pipe of spirits at 85°, the quantity being 632 litres, into brandy at 46°. The table indicates that it requires 89.1 litres of water to reduce 100 litres of spirit at 85° to spirit at 46°. Multiply 632 by 89.1, and we obtain the product, 563.112, which being divided by 100 gives 563.1 litres for the quantity of water to be added to the amount of spirits given.

Second Example.—It is required to reduce 40 litres of brandy at 58° to brandy at 49°. The table indicates for 100 litres of spirit, 19 litres of water; multiply 40 by 19 gives 760, which divided by 100 gives 7.6 litres as the quantity of water to be added to the brandy.

When it is proposed to obtain from a spirit of known strength, a certain measure of another spirit of inferior degree, the quantity of spirit necessary to be employed is found *by multiplying the given measure by the number*

indicating the degree of the weaker spirit and divide the product by the number indicating the degree of the stronger or given spirit.

Example.—Given spirit at 85° from which it is required to make 340 litres at 49°. According to the rule, multiply 340, the given quantity of spirits, by 49, the degree to be produced, and we have 16660, which divided by 85 gives 196 litres, which is the quantity of spirit at 85° necessary for producing 340 litres of brandy at 49°. Now we ascertain that the quantity of water to be added to 100 litres of this spirit, by consulting the table for reducing, to dilute it to 49°, is 77.6 litres, and on multiplying this by 196, and dividing by 100, we have 151.9 litres for the quantity of water necessary for the operation.

Second Example.—Given a spirit at 90°, it is required to produce from it 250 litres at 46°, multiply 250 by 46, and we have 11500; divide by 90, and we get 127 litres. It requires, then, 127 litres of spirit at 90° to produce 250 litres at 46°; seek in the table for reducing spirits for the quantity of water necessary to reduce 100 litres of this spirit to 46°, and proceed as in the last case.

Sometimes a liquor is reduced by the addition of a spirit of inferior strength; but as these liquids when mixed do not exhibit anything like as great an amount of contraction as when they are mixed with water, we can obtain a result which is quite accurate enough for all practical purposes by considering this contraction as nothing. The question of reducing, then, becomes very simple, and is a matter of average.

Example.—Let us suppose that we have 615 litres of spirit at 86° which is to be reduced to 47° by means of brandy at 36°. What quantity of the weaker spirit will be required? Multiply 615 by 39, which is the difference between 86 and 47, and divide the product 23985 by 11, which is the difference between 47 and 36, and the quotient 2180 will represent the number of litres of brandy at 36° required for the operation.

When the quantity of the stronger spirit is the unknown quantity, the operation is just the reverse of the preceding, as, for example, if it is required to produce a spirit at 47° from 2180 litres of brandy at 36°, by means of spirit at 86°. The necessary volume of the last will be ascertained by multiplying 2180 by 11 (the difference between 47 and 36), and dividing the product by 39 (the difference between 86 and 47), which will give for a quotient 614, representing the number of litres of spirit at 86° sought for. This is *raising the proof*, and is the reverse of the preceding operation.

TABLE *for reducing Spirituous Liquors, indicating the quantity of water necessary to reduce one hectolitre of spirits from a higher to an inferior degree.*

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
94°	38°	147 6	94°	84°	12 7	93°	73°	29 0	92°	63	48 6
“	39	141 5	“	85	11 4	“	74	27 2	“	64	46 2
“	40	135 6	“	86	10 0	“	75	25 5	“	65	43 9
“	41	130 0	“	87	8 7	“	76	23 8	“	66	41 7
“	42	124 7	“	88	7 4	“	77	22 1	“	67	39 6
“	43	119 6	“	89	6 1	“	78	20 5	“	68	37 5
“	44	114 8	“	90	4 8	“	79	18 9	“	69	35 5
“	45	110 1	“	91	3 6	“	80	17 4	“	70	33 5
“	46	105 7	“	92	2 4	“	81	15 9	“	71	31 5
“	47	101 4	“	93	1 2	“	82	14 4	“	72	29 7
“	48	97 3				“	83	13 0	“	73	27 8
“	49	93 4	93°	38°	146 4	“	84	11 5	“	74	26 0
“	50	89 6	“	39	140 3	“	85	10 2	“	75	24 3
“	51	86 0	“	40	134 4	“	86	8 8	“	76	22 6
“	52	82 5	“	41	128 8	“	87	7 5	“	77	20 9
“	53	79 1	“	42	123 5	“	88	6 2	“	78	19 3
“	54	75 8	“	43	118 4	“	89	4 9	“	79	17 7
“	55	72 7	“	44	113 6	“	90	3 6	“	80	16 2
“	56	69 6	“	45	108 9	“	91	2 4	“	81	14 7
“	57	66 7	“	46	104 5	“	92	1 2	“	82	13 2
“	58	63 9	“	47	100 2				“	83	11 8
“	59	61 1	“	48	96 1	92°	38°	145 2	“	84	10 3
“	60	58 5	“	49	92 2	“	39	139 1	“	85	9 0
“	61	55 9	“	50	88 4	“	40	133 2	“	86	7 6
“	62	53 4	“	51	84 8	“	41	127 6	“	87	6 3
“	63	51 0	“	52	81 3	“	42	122 3	“	88	5 0
“	64	48 6	“	53	77 9	“	43	117 2	“	89	3 7
“	65	46 3	“	54	74 6	“	44	112 4	“	90	2 4
“	66	44 1	“	55	71 5	“	45	107 7	“	91	1 2
“	67	42 0	“	56	68 4	“	46	103 3			
“	68	39 9	“	57	65 5	“	47	99 0	91°	38°	144 0
“	69	37 9	“	58	62 7	“	48	94 9	“	39	137 9
“	70	35 9	“	59	59 9	“	49	91 0	“	40	132 0
“	71	33 9	“	60	57 3	“	50	87 2	“	41	126 4
“	72	32 1	“	61	54 7	“	51	83 6	“	42	121 1
“	73	30 2	“	62	52 2	“	52	80 1	“	43	116 0
“	74	28 4	“	63	49 8	“	53	76 7	“	44	111 2
“	75	26 7	“	64	47 4	“	54	73 4	“	45	106 5
“	76	25 0	“	65	45 1	“	55	70 3	“	46	102 1
“	77	23 3	“	86	42 9	“	56	67 2	“	47	97 8
“	78	21 7	“	67	40 8	“	57	64 3	“	48	93 7
“	79	20 1	“	68	38 7	“	58	61 5	“	49	89 8
“	80	18 6	“	69	36 7	“	59	58 7	“	50	86 0
“	81	17 1	“	70	34 7	“	60	56 1	“	51	82 4
“	82	15 6	“	71	32 7	“	61	53 5	“	52	78 9
“	83	14 2	“	72	30 9	“	62	51 0	“	53	75 5

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
91°	54°	72 2	90	53°	74 3	89°	53°	72 2	88°	54°	66 9
"	55	69 1	"	54	71 0	"	54	69 0	"	55	63 9
"	56	66 0	"	55	67 9	"	55	65 9	"	56	60 9
"	57	63 1	"	56	64 8	"	56	62 9	"	57	58 0
"	58	60 3	"	57	61 9	"	57	60 0	"	58	55 3
"	59	57 5	"	58	59 1	"	58	57 2	"	59	52 6
"	60	54 9	"	59	56 3	"	59	54 4	"	60	50 0
"	61	52 3	"	60	53 7	"	60	51 8	"	61	47 4
"	62	49 8	"	61	51 1	"	61	49 3	"	62	45 0
"	63	47 4	"	62	48 6	"	62	46 8	"	63	42 6
"	64	45 0	"	63	46 2	"	63	44 4	"	64	40 3
"	65	42 7	"	64	43 8	"	64	42 1	"	65	38 1
"	66	40 5	"	65	41 5	"	65	39 8	"	66	35 9
"	67	38 4	"	66	39 3	"	66	37 6	"	67	33 8
"	66	36 3	"	67	37 2	"	67	35 5	"	68	31 8
"	69	34 3	"	68	35 1	"	68	33 4	"	69	29 8
"	70	32 3	"	69	33 1	"	69	31 4	"	70	27 9
"	71	30 3	"	70	31 1	"	70	29 5	"	71	26 0
"	72	28 5	"	71	29 1	"	71	27 5	"	72	24 1
"	73	26 6	"	72	27 3	"	72	25 7	"	73	22 3
"	74	24 8	"	73	25 4	"	73	23 9	"	74	20 6
"	75	23 1	"	74	23 6	"	74	22 1	"	75	18 9
"	76	21 4	"	75	21 9	"	75	20 4	"	76	17 2
"	77	19 7	"	76	20 2	"	76	18 7	"	77	15 6
"	78	18 1	"	77	18 5	"	77	17 1	"	78	14 0
"	79	16 5	"	78	16 9	"	78	15 5	"	79	12 5
"	80	15 0	"	79	15 3	"	79	13 9	"	80	11 0
"	81	13 5	"	80	13 8	"	80	12 4	"	81	9 5
"	82	12 0	"	81	12 3	"	81	10 9	"	82	8 1
"	83	10 6	"	82	10 8	"	82	9 4	"	83	6 6
"	84	9 1	"	83	9 4	"	83	8 0	"	84	5 3
"	85	7 8	"	84	7 9	"	84	6 6	"	85	3 9
"	86	6 4	"	85	6 6	"	85	5 2	"	86	2 6
"	87	5 1	"	86	5 2	"	86	3 9	"	87	1 3
"	88	3 8	"	87	3 9	"	87	2 6			
"	89	2 5	"	88	2 6	"	88	1 3	87°	38°	134 3
"	90	1 3	"	89	1 3				"	39	128 4
						88°	38	137 1	"	40	122 7
90°	38	142 8	89°	38°	140 0	"	39	131 1	"	41	117 3
"	39	136 7	"	39	133 9	"	40	125 4	"	42	112 2
"	40	130 8	"	40	128 1	"	41	120 0	"	43	107 3
"	41	125 2	"	41	122 6	"	42	114 7	"	44	102 6
"	42	119 9	"	42	117 3	"	43	109 8	"	45	98 1
"	43	114 8	"	43	112 3	"	44	105 0	"	46	93 8
"	44	110 0	"	44	107 5	"	45	100 5	"	47	89 7
"	45	105 3	"	45	102 9	"	46	96 1	"	48	85 7
"	46	100 9	"	46	98 5	"	47	92 0	"	49	81 9
"	47	96 6	"	47	94 3	"	48	88 0	"	50	78 2
"	48	92 5	"	48	90 2	"	49	84 1	"	51	74 7
"	49	88 6	"	49	86 3	"	50	80 4	"	52	71 3
"	50	84 8	"	50	82 6	"	51	76 9	"	53	68 1
"	51	81 2	"	51	79 0	"	52	73 4	"	54	64 9
"	52	77 7	"	52	75 5	"	53	70 1	"	55	61 9

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
87°	56°	58 9	86°	59°	48 8	85°	63°	37 4	84°	68°	25 3
"	57	56 1	"	60	46 3	"	64	35 2	"	69	23 4
"	58	53 4	"	61	43 8	"	65	33 0	"	70	21 6
"	59	50 7	"	62	41 5	"	66	30 9	"	71	19 8
"	60	48 1	"	63	39 1	"	67	28 9	"	72	18 0
"	61	45 6	"	64	36 9	"	68	26 9	"	73	16 3
"	62	43 2	"	65	34 7	"	69	25 0	"	74	14 6
"	63	40 9	"	66	32 6	"	70	23 1	"	75	13 0
"	64	38 6	"	67	30 5	"	71	21 3	"	76	11 4
"	65	36 4	"	68	28 5	"	72	19 5	"	77	9 9
"	66	34 3	"	69	26 6	"	73	17 8	"	78	8 4
"	67	32 2	"	70	24 7	"	74	16 1	"	79	6 9
"	68	30 2	"	71	22 9	"	75	14 5	"	80	5 5
"	69	28 2	"	72	21 1	"	76	12 9	"	81	4 0
"	70	26 3	"	73	19 3	"	77	11 3	"	82	2 7
"	71	24 4	"	74	17 6	"	78	9 8	"	83	1 3
"	72	22 6	"	75	15 9	"	79	8 3			
"	73	20 8	"	76	14 3	"	80	6 8	83°	38°	123 1
"	74	19 1	"	77	12 7	"	81	5 4	"	39	117 4
"	75	17 4	"	78	11 2	"	82	4 0	"	40	112 0
"	76	15 8	"	79	9 7	"	83	2 6	"	41	106 9
"	77	14 2	"	80	8 2	"	84	1 3	"	42	102 0
"	78	12 6	"	81	6 8				"	43	97 3
"	79	11 1	"	82	5 4	84°	38°	125 9	"	44	92 8
"	80	9 6	"	83	4 0	"	39	120 1	"	45	88 5
"	81	8 1	"	84	2 6	"	40	114 7	"	46	84 4
"	82	6 7	"	85	1 3	"	41	109 5	"	47	80 5
"	83	5 3				"	42	104 5	"	48	76 7
"	84	3 9	85°	38°	128 7	"	43	99 8	"	49	73 1
"	85	2 6	"	39	122 9	"	44	95 5	"	50	69 6
"	86	1 3	"	40	117 3	"	45	90 9	"	51	66 2
			"	41	112 1	"	46	86 7	"	52	63 0
86°	38°	131 5	"	42	107 1	"	47	82 8	"	53	59 9
"	39	125 6	"	43	102 3	"	48	78 9	"	54	56 9
"	40	120 0	"	44	97 7	"	49	75 3	"	55	54 0
"	41	114 7	"	45	93 3	"	50	71 7	"	56	51 2
"	42	109 6	"	46	89 1	"	51	68 3	"	57	48 5
"	43	104 8	"	47	85 1	"	52	65 1	"	58	45 8
"	44	100 1	"	48	81 2	"	53	61 9	"	59	43 3
"	45	95 7	"	49	77 5	"	54	58 9	"	60	40 9
"	46	91 4	"	50	73 9	"	55	55 9	"	61	38 5
"	47	87 4	"	51	70 5	"	56	53 1	"	62	36 2
"	48	83 4	"	52	67 1	"	57	50 4	"	63	33 9
"	49	79 7	"	53	64 0	"	58	47 7	"	64	31 8
"	50	76 1	"	54	60 9	"	59	45 1	"	65	29 7
"	51	72 6	"	55	57 9	"	60	42 7	"	66	27 6
"	52	69 2	"	56	55 0	"	61	40 3	"	67	25 6
"	53	66 0	"	57	52 3	"	62	37 9	"	68	23 7
"	54	62 9	"	58	49 6	"	63	35 7	"	69	21 8
"	55	57 9	"	59	47 0	"	64	33 5	"	70	20 0
"	56	57 0	"	60	44 5	"	65	31 3	"	71	18 2
"	57	54 2	"	61	42 1	"	66	29 3	"	72	16 5
"	58	51 5	"	62	39 7	"	67	27 3	"	73	14 8

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
83°	74°	13 1	82°	81°	1 3	80°	45	81 3	79°	55°	46 1
"	75	11 6				"	46	77 4	"	56	43 4
"	76	10 0	81°	38	117 5	"	47	73 6	"	57	40 9
"	77	8 5	"	39	111 9	"	48	70 0	"	58	38 4
"	78	7 0	"	40	106 7	"	49	66 5	"	59	36 0
"	79	5 5	"	41	101 7	"	50	63 1	"	60	33 6
"	80	4 1	"	42	96 9	"	51	59 9	"	61	31 4
"	81	2 7	"	43	92 3	"	52	56 8	"	62	29 2
"	82	1 3	"	44	87 9	"	53	53 8	"	63	27 1
			"	45	83 7	"	54	50 9	"	64	25 0
82°	38°	120 3	"	46	79 7	"	55	48 1	"	65	23 0
"	39	114 7	"	47	75 9	"	56	45 4	"	66	21 1
"	40	109 3	"	48	72 2	"	57	42 8	"	67	19 2
"	41	104 3	"	49	68 7	"	58	40 2	"	68	17 3
"	42	99 4	"	50	65 3	"	59	37 8	"	69	15 5
"	43	94 8	"	51	62 0	"	60	35 4	"	70	13 8
"	44	90 4	"	52	58 8	"	61	33 1	"	71	12 1
"	45	86 1	"	53	55 8	"	62	30 9	"	72	10 5
"	46	82 1	"	54	52 9	"	63	28 8	"	73	8 8
"	47	78 2	"	55	50 0	"	64	26 7	"	74	7 3
"	48	74 5	"	56	47 3	"	65	24 7	"	75	5 7
"	49	70 9	"	57	44 7	"	66	22 7	"	76	4 3
"	50	67 4	"	58	42 1	"	67	20 8	"	77	2 8
"	51	64 1	"	59	39 6	"	68	18 9	"	78	1 4
"	52	60 9	"	60	37 2	"	69	17 1			
"	53	57 8	"	61	34 9	"	70	15 3	78°	38°	109 1
"	54	54 9	"	62	32 7	"	71	13 6	"	39	103 8
"	55	52 0	"	63	30 5	"	72	12 0	"	40	98 7
"	56	49 2	"	64	28 4	"	73	10 3	"	41	93 9
"	57	46 5	"	65	26 3	"	74	8 7	"	42	89 3
"	58	44 0	"	66	24 3	"	75	7 2	"	43	84 9
"	59	41 5	"	67	22 4	"	76	5 7	"	44	80 7
"	60	39 0	"	68	20 5	"	77	4 2	"	45	76 6
"	61	36 7	"	69	18 7	"	78	2 8	"	46	72 8
"	62	34 4	"	70	16 9	"	79	1 4	"	47	69 1
"	63	32 2	"	71	15 2				"	48	65 5
"	64	30 1	"	72	13 5	79°	38°	111 9	"	49	62 1
"	65	28 0	"	73	11 8	"	39	106 5	"	50	58 8
"	66	26 0	"	74	10 2	"	40	101 4	"	51	55 7
"	67	24 0	"	75	8 6	"	41	96 5	"	52	52 7
"	68	22 1	"	76	7 1	"	42	91 8	"	53	49 7
"	69	20 3	"	77	5 6	"	43	87 3	"	54	46 9
"	70	18 4	"	78	4 2	"	44	83 1	"	55	44 2
"	71	16 7	"	79	2 7	"	45	79 0	"	56	41 5
"	72	15 0	"	80	1 4	"	46	75 1	"	57	39 0
"	73	13 3				"	47	71 3	"	58	36 5
"	74	11 7	80°	38	114 7	"	48	67 8	"	59	34 1
"	75	10 1	"	39	109 2	"	49	64 3	"	60	31 8
"	76	8 5	"	40	104 0	"	50	61 0	"	61	29 6
"	77	7 0	"	41	99 1	"	51	57 8	"	62	27 4
"	78	5 6	"	42	94 3	"	52	54 7	"	63	25 3
"	79	4 1	"	43	89 8	"	53	51 7	"	64	23 3
"	80	2 7	"	44	85 5	"	54	48 9	"	65	21 3

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
78°	66°	19 4	76°	38°	103 5	75°	52°	46 5	74°	67°	11 1
“	67	17 6	“	39	98 3	“	53	43 7	“	68	9 4
“	68	15 7	“	40	93 4	“	54	40 9	“	69	7 7
“	69	14 0	“	41	88 7	“	55	38 3	“	70	6 1
“	70	12 3	“	42	84 2	“	56	35 8	“	71	4 5
“	71	10 6	“	43	79 9	“	57	33 3	“	72	3 0
“	72	9 0	“	44	75 8	“	58	31 0	“	73	1 5
“	73	7 4	“	45	71 2	“	59	28 7			
“	74	5 8	“	46	68 1	“	60	26 5	73°	38°	95 2
“	75	4 3	“	47	64 5	“	61	24 3	“	39	90 2
“	76	2 8	“	48	61 1	“	62	22 2	“	40	85 5
“	77	1 4	“	49	57 8	“	63	20 2	“	41	81 0
			“	50	54 6	“	64	18 3	“	42	76 7
77°	38°	106 3	“	51	51 5	“	65	16 4	“	43	72 5
“	39	101 1	“	52	48 5	“	66	14 5	“	44	68 6
“	40	96 1	“	53	45 7	“	67	12 7	“	45	64 8
“	41	91 3	“	54	42 9	“	68	11 0	“	46	61 2
“	42	86 7	“	55	40 3	“	69	9 3	“	47	57 8
“	43	82 4	“	56	37 7	“	70	7 6	“	48	54 4
“	44	78 2	“	57	35 2	“	71	6 0	“	49	51 2
“	45	74 3	“	58	32 8	“	72	4 5	“	50	48 2
“	46	70 5	“	59	30 5	“	73	2 9	“	51	45 2
“	47	66 8	“	60	28 3	“	74	1 4	“	52	42 4
“	48	63 3	“	61	26 1				“	53	39 6
“	49	59 9	“	62	24 0	74°	38°	98 0	“	54	37 0
“	50	56 7	“	63	21 9	“	39	92 9	“	55	34 4
“	51	53 6	“	64	19 9	“	40	88 1	“	56	32 0
“	52	50 6	“	65	18 0	“	41	83 5	“	57	29 6
“	53	47 7	“	66	16 2	“	42	79 2	“	58	27 3
“	54	44 9	“	67	14 3	“	43	75 0	“	59	25 1
“	55	42 2	“	68	12 6	“	44	71 0	“	60	22 9
“	56	39 6	“	69	10 9	“	45	67 2	“	61	20 8
“	57	37 1	“	70	9 2	“	46	63 5	“	62	18 8
“	58	34 7	“	71	7 5	“	47	60 0	“	63	16 8
“	59	32 3	“	72	6 0	“	48	56 7	“	64	14 9
“	60	30 0	“	73	4 4	“	49	53 4	“	65	13 1
“	61	27 8	“	74	2 9	“	50	50 3	“	66	11 3
“	62	25 7	“	75	1 4	“	51	47 3	“	67	9 5
“	63	23 6				“	52	44 4	“	68	7 8
“	64	21 6	75°	38°	100 8	“	53	41 6	“	69	6 2
“	65	19 7	“	39	95 6	“	54	39 0	“	70	4 6
“	66	17 8	“	40	90 8	“	55	36 4	“	71	3 0
“	67	15 9	“	41	86 1	“	56	33 9	“	72	1 5
“	68	14 2	“	42	81 7	“	57	31 5			
“	69	12 4	“	43	77 5	“	58	29 1	72°	38°	92 4
“	70	10 7	“	44	73 4	“	59	26 9	“	39	87 5
“	71	9 1	“	45	69 5	“	60	24 7	“	40	82 8
“	72	7 5	“	46	65 8	“	61	22 6	“	41	78 4
“	73	5 9	“	47	62 3	“	62	20 5	“	42	74 1
“	74	4 4	“	48	58 9	“	63	18 5	“	43	70 1
“	75	2 9	“	49	55 6	“	64	16 6	“	44	66 2
“	76	1 4	“	50	52 4	“	65	14 7	“	45	62 5
			“	51	49 4	“	66	12 9	“	46	58 9

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
72°	47°	55 5	71°	65°	9 8	69°	51°	36 9	67°	41°	65 6
"	48	52 2	"	66	8 0	"	52	34 2	"	42	61 6
"	49	49 1	"	67	6 3	"	53	31 6	"	43	57 8
"	50	46 0	"	68	4 7	"	54	29 1	"	44	54 2
"	51	43 1	"	69	3 1	"	55	26 7	"	45	50 8
"	52	40 3	"	70	1 5	"	56	24 4	"	46	47 4
"	53	37 6				"	57	22 1	"	47	44 3
"	54	35 0	70°	38°	86 9	"	58	20 0	"	48	41 2
"	55	32 5	"	39	82 1	"	59	17 8	"	49	38 3
"	56	30 1	"	40	77 6	"	60	15 8	"	50	35 5
"	57	27 7	"	41	73 2	"	61	13 8	"	51	32 8
"	58	25 5	"	42	69 1	"	62	11 9	"	52	30 1
"	59	23 2	"	43	65 2	"	63	10 1	"	53	27 6
"	60	21 1	"	44	61 4	"	64	8 2	"	54	25 2
"	61	19 1	"	45	57 8	"	65	6 5	"	55	22 9
"	62	17 1	"	46	54 3	"	66	4 8	"	56	20 6
"	63	15 1	"	47	51 0	"	67	3 2	"	57	18 4
"	64	13 2	"	48	47 8	"	68	1 6	"	58	16 3
"	65	11 4	"	49	44 7				"	59	14 3
"	66	9 7	"	50	41 8	68°	38°	81 4	"	60	12 3
"	67	7 9	"	51	39 0	"	39	76 7	"	61	10 4
"	68	6 3	"	52	36 2	"	40	72 3	"	62	8 5
"	69	4 6	"	53	33 6	"	41	68 1	"	63	6 7
"	70	3 0	"	54	31 1	"	42	64 1	"	64	4 9
"	71	1 5	"	55	28 6	"	43	60 3	"	65	3 2
			"	56	26 3	"	44	56 6	"	66	1 6
71°	38°	89 7	"	57	24 0	"	45	53 1			
"	39	84 8	"	58	21 8	"	46	49 7	66°	38°	75 9
"	40	80 2	"	59	19 6	"	47	46 5	"	39	71 4
"	41	75 8	"	60	17 6	"	48	43 4	"	40	67 1
"	42	71 6	"	61	15 6	"	49	40 4	"	41	63 0
"	43	67 6	"	62	13 6	"	50	37 6	"	42	59 1
"	44	63 8	"	63	11 7	"	51	34 8	"	43	55 4
"	45	60 1	"	64	9 7	"	52	32 2	"	44	51 8
"	46	56 6	"	65	8 1	"	53	29 6	"	45	48 4
"	47	53 2	"	66	6 4	"	54	27 2	"	46	46 1
"	48	50 0	"	67	4 7	"	55	24 8	"	47	42 0
"	49	46 9	"	68	3 1	"	56	22 5	"	48	39 0
"	50	43 9	"	69	1 5	"	57	20 3	"	49	36 1
"	51	41 1				"	58	18 1	"	50	33 4
"	52	38 3	69°	38°	84 1	"	59	16 0	"	51	30 7
"	53	35 6	"	39	79 4	"	60	14 0	"	52	28 1
"	54	33 1	"	40	75 0	"	61	12 1	"	53	25 6
"	55	30 6	"	41	70 7	"	62	10 2	"	54	23 2
"	56	28 2	"	42	66 6	"	63	9 4	"	55	20 9
"	57	25 9	"	43	62 7	"	64	6 6	"	56	18 7
"	58	23 6	"	44	59 0	"	65	4 9	"	57	16 6
"	59	21 4	"	45	55 4	"	66	3 2	"	58	14 5
"	60	19 3	"	46	52 0	"	67	1 6	"	59	12 5
"	61	17 3	"	47	48 7				"	60	10 5
"	62	15 3	"	48	45 6	67°	38°	78 6	"	61	8 6
"	63	13 4	"	49	42 6	"	39	74 1	"	62	6 8
"	64	11 6	"	50	39 7	"	40	69 7	"	63	5 0

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
66°	64°	3 3	64°	60°	7 0	62°	60°	3 6	59°	41°	45 2
"	65	1 6	"	61	5 2	"	61	1 7	"	42	41 7
			"	62	3 4				"	43	38 4
65°	38°	73 1	"	63	1 7	61°	38°	62 2	"	44	35 2
"	39	68 7				"	39	58 0	"	45	32 1
"	40	64 5	63°	38°	67 6	"	40	54 0	"	46	29 2
"	41	60 5	"	39	63 3	"	41	50 3	"	47	26 4
"	42	56 6	"	40	59 3	"	42	46 7	"	48	23 7
"	43	52 9	"	41	55 4	"	43	43 2	"	49	21 2
"	44	49 4	"	42	51 6	"	44	39 9	"	50	18 7
"	45	46 1	"	43	48 1	"	45	36 8	"	51	16 3
"	46	42 9	"	44	44 7	"	46	33 8	"	52	14 0
"	47	39 8	"	55	41 4	"	47	30 9	"	53	11 8
"	48	36 8	"	46	38 3	"	48	28 1	"	54	9 6
"	49	34 0	"	47	35 3	"	49	25 4	"	55	7 6
"	50	31 3	"	48	32 5	"	50	22 9	"	56	5 6
"	51	28 6	"	49	29 7	"	51	20 4	"	57	3 7
"	52	26 1	"	50	27 1	"	52	18 0	"	58	1 8
"	53	23 7	"	51	24 5	"	53	15 7			
"	54	21 3	"	52	22 1	"	54	13 5	58°	38°	54 0
"	55	19 0	"	53	19 7	"	55	11 4	"	39	50 0
"	56	16 8	"	54	17 4	"	56	9 3	"	40	46 2
"	57	14 7	"	55	15 2	"	57	7 3	"	41	42 6
"	58	12 7	"	56	13 1	"	58	5 4	"	42	39 2
"	59	10 7	"	57	11 0	"	59	3 5	"	43	35 9
"	60	8 8	"	58	9 0	"	60	1 7	"	44	32 8
"	61	6 9	"	59	7 1				"	45	29 8
"	62	5 1	"	60	5 2	60°	38°	69 4	"	46	26 9
"	63	3 3	"	61	3 4	"	39	55 3	"	47	24 2
"	64	1 6	"	62	1 7	"	40	51 4	"	48	21 6
						"	41	47 7	"	49	19 0
64°	38°	70 4	62°	38°	64 9	"	42	44 2	"	50	16 6
"	39	66 0	"	39	60 7	"	43	40 8	"	51	14 2
"	40	61 9	"	40	57 6	"	44	37 5	"	52	12 0
"	41	57 9	"	41	52 8	"	45	34 5	"	53	9 9
"	42	54 1	"	42	49 1	"	46	31 5	"	54	7 7
"	43	50 5	"	43	45 6	"	47	28 6	"	55	5 7
"	44	47 1	"	44	42 3	"	48	25 9	"	56	3 7
"	45	43 8	"	45	39 1	"	49	23 3	"	57	1 8
"	46	40 6	"	46	36 0	"	50	20 8			
"	47	37 6	"	47	33 1	"	51	18 3	57°	38°	51 2
"	48	34 6	"	48	30 3	"	62	16 0	"	39	47 3
"	49	31 8	"	49	27 6	"	53	13 7	"	40	43 6
"	50	29 2	"	50	25 0	"	54	11 6	"	41	40 1
"	51	26 6	"	51	22 5	"	55	9 5	"	42	36 7
"	52	24 1	"	52	20 0	"	56	7 4	"	43	33 5
"	53	21 7	"	53	17 7	"	57	5 5	"	44	30 5
"	54	19 4	"	54	15 5	"	58	3 6	"	45	27 5
"	55	17 1	"	55	13 3	"	59	1 8	"	46	24 7
"	56	15 0	"	56	11 2				"	47	22 0
"	57	12 8	"	57	9 2	59°	38°	56 7	"	48	19 4
"	58	10 9	"	58	7 2	"	39	52 7	"	49	16 9
"	59	8 9	"	59	5 3	"	40	48 8	"	50	14 5

Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced.	Quantity of water required.	Degree to be reduced.	Degree to be produced	Quantity of water required.
from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.	from	to	lit. dec.
57°	51°	12 2	54°	43°	26 3	51°	44°	16 3	47°	43°	9 5
"	52	10 0	"	44	23 4	"	45	13 7	"	44	7 0
"	53	7 8	"	45	20 6	"	46	11 2	"	45	4 6
"	54	5 8	"	46	17 9	"	47	8 7	"	46	2 2
"	55	3 8	"	47	15 3	"	48	6 4			
"	56	1 9	"	48	12 9	"	49	4 2	46°	38°	21 4
			"	49	10 5	"	50	2 1	"	39	18 3
56°	38°	48 5	"	50	8 3				"	40	15 3
"	39	44 7	"	51	6 1	50°	38°	32 2	"	41	12 4
"	40	41 1	"	52	4 0	"	39	28 8	"	42	9 7
"	41	37 6	"	53	1 9	"	40	25 6	"	43	7 0
"	42	34 3				"	41	22 5	"	44	4 6
"	43	31 1	53°	38°	40 3	"	42	19 5	"	45	2 3
"	44	28 1	"	39	36 7	"	43	16 7			
"	45	25 2	"	40	33 3	"	44	14 0	45°	38°	18 7
"	46	22 4	"	41	30 0	"	45	11 4	"	39	15 7
"	47	19 8	"	42	26 9	"	46	8 9	"	40	12 7
"	48	17 2	"	43	23 9	"	47	6 6	"	41	9 9
"	49	14 8	"	44	21 0	"	48	4 3	"	42	7 3
"	50	12 4	"	45	18 3	"	49	2 1	"	43	4 7
"	51	10 2	"	46	15 7				"	44	2 3
"	52	8 0	"	47	13 2	49°	38°	29 5			
"	53	5 9	"	48	10 7	"	39	26 2	44°	38°	16 0
"	54	3 8	"	49	8 4	"	40	23 0	"	39	13 0
"	55	1 9	"	50	6 2	"	41	20 0	"	40	10 2
			"	51	4 1	"	42	17 1	"	41	7 5
55°	38°	45 8	"	52	2 0	"	43	14 3	"	42	4 9
"	39	42 0				"	44	11 6	"	43	2 4
"	40	38 5	52°	38°	37 6	"	45	9 1			
"	41	35 0	"	39	34 1	"	46	6 7	43°	38°	13 4
"	42	31 8	"	40	30 7	"	47	4 4	"	39	10 4
"	43	28 7	"	41	27 5	"	48	2 1	"	40	7 6
"	44	25 7	"	42	24 4				"	41	5 0
"	45	22 9	"	43	21 5	48°	38°	26 8	"	42	2 4
"	46	20 2	"	44	18 7	"	39	23 5			
"	47	17 6	"	45	16 0	"	40	20 4	42°	38°	10 7
"	48	15 1	"	46	13 4	"	41	17 4	"	39	7 8
"	49	12 7	"	47	11 0	"	42	14 6	"	40	5 1
"	50	10 3	"	48	8 6	"	43	11 9	"	41	2 5
"	51	8 1	"	49	6 3	"	44	9 3			
"	52	6 0	"	50	4 1	"	45	6 8	41°	38°	8 0
"	53	3 9	"	51	2 0	"	46	4 5	"	39	5 2
"	54	1 9				"	47	2 2	"	40	2 5
			51°	38°	34 9						
54°	38°	43 1	"	39	31 4	47°	38°	24 1	40°	38°	5 3
"	39	39 4	"	40	28 1	"	39	20 9	"	39	2 6
"	40	35 9	"	41	25 0	"	40	17 9			
"	41	32 5	"	42	22 0	"	41	14 9	39°	38°	2 7
"	42	29 3	"	43	19 1	"	42	12 2			

Raising the Proof of Brandy.

The augmentation of the strength or degree of a spirituous liquor, by means of another spirituous liquor, is known, in the trade, as *raising the proof* (*remontage*). We have already given an example of this operation in speaking of the reduction of one liquor by means of another; nevertheless, we think it better to present another example, in order to explain more fully the manner of conducting the operation.

We will suppose that a cask, containing 420 litres of brandy at 46 degrees, is to have its standard of proof raised to 49 degrees by the addition of spirit at 85 degrees.

We take the difference between 43 and 46, and multiply this difference by the number of litres ($420 \times 3 = 1260$); divide the product by 36, the difference between 85 and 49, and we have 36 for the number of litres of spirit at 85°, to be added to 420 litres of brandy at 46° to raise the proof to 49°. The operation yields 455 litres.

[*Rule.*—Multiply the number representing the quantity of spirits to be raised by the difference between its degree and that of the new compound; divide this product by the difference between the degree of the stronger spirit and that of the new compound; the quotient will indicate the quantity of strong spirit necessary to increase the standard or proof of the weaker liquor.]—*Trans.*

TABLE *exhibiting the actual value of spirits at 85 degrees centesimal (33° Cartier) reduced to all degrees of proof found in the market.*

Cost of a hectolitre in francs.	41° or 17° Cartier.	43° or 17½° Cartier.	45° or 18° Cartier.	47° or 18½° Cartier.	49° or 19° Cartier.	50° or 19¼° Cartier.	51° or 19½° Cartier.	53° or 20° Cartier.	58° or 21¾° Cartier.	59° or 22¼° Cartier.
fr.	fr	fr.	fr.	fr.	fr.	fr.	fr.	fr.	fr.	fr.
35	16.97	17.82	18.61	19.46	20.27	20.68	21.10	21.94	23.97	24.36
36	17.45	18.32	19.14	20.01	20.84	21.27	21.70	22.56	24.65	25.06
37	17.93	18.83	19.67	20.56	21.42	21.86	22.30	23.18	25.33	25.76
38	18.42	19.33	20.20	21.12	21.99	22.44	22.90	23.81	26.02	26.46
39	18.90	19.84	20.73	21.67	22.57	23.03	23.50	24.43	26.70	27.16
40	19.38	20.34	21.26	22.22	23.14	23.62	24.10	25.06	27.38	27.86
41	19.86	20.85	21.79	22.77	23.72	24.21	24.70	25.68	28.06	28.55
42	20.34	21.35	22.32	23.33	24.29	24.80	25.30	26.31	28.74	29.24
43	20 83	21.86	22.85	23.88	24.87	25.38	25.90	26.93	29.43	29.94
44	21.31	22.36	23.38	24.43	25.44	25.97	26.50	27.56	30.11	30.63
45	21.79	22.87	23.91	24.99	26.02	26.56	27.10	28.18	30.79	31.33
46	22.27	23.38	24.43	25.54	26.60	27.15	27.70	28.80	31.47	32.02
47	22.75	23.88	24.96	26.09	27.17	27.74	28.30	29.43	32.15	32.71
48	23.24	24.39	25.49	26.64	27.75	28.32	28.90	30.05	32 84	33.42
49	23.72	24.89	26.02	27.20	28.32	28.91	29.50	30.68	33.52	34.10
50	24.20	25.40	26.55	27.75	28.90	29.50	30.10	31.30	34.20	34.80
51	24.68	25.91	27.08	28.30	29.48	30.09	30.70	31.92	34.88	35.49
52	25.16	26.41	27.61	28.86	30.05	30.68	31.30	32.55	35.56	36.18
53	25.65	26.92	28.14	29.41	30.63	31.26	31.90	33.17	36.25	36.88
54	26.13	27.42	28.67	29.96	31.20	31.85	32.50	33.80	36.93	37.57
55	26.61	27.93	29.20	30.52	31.78	32.44	33.10	34.42	37.61	38.27
56	27.09	28.44	29.72	31.07	32.36	33.03	33.70	35.04	38.29	38.96
57	27.57	28.94	30.25	31.62	32.93	33.62	34.30	35.67	38.97	39.65
58	28.06	29.45	30.78	32.17	33.51	34.20	34.90	36.29	39.66	40.35
59	28.54	29.95	31.31	32.73	34.08	34,79	35.50	36.92	40.34	41.04
60	29.02	30.46	31.84	33.28	34.66	35.38	36.10	37.54	41.02	41.74
61	29.50	30.97	32.37	33.93	35.24	35.97	36.70	38.16	41.70	42.43
62	29.98	31.47	32.90	34.39	35.81	36.56	37.30	38.79	42.38	43.12
63	30.47	31.98	33.43	34.94	36.39	37.14	37.90	39 41	43.07	43.72
64	30.95	32.48	33.96	35.49	36.96	37.73	38.50	40.04	43.75	44.51
65	31.43	32.99	34.49	36.05	37.54	38.32	39.10	40.66	44.43	45.21
66	31.91	33.50	35.01	36.60	38.12	38.91	39.70	41.28	45.11	45.91
67	32.39	34.00	35.54	37.15	38.69	39.50	40.30	41.91	45.79	46.59
68	32.88	34.51	36.07	37.70	39.27	40.08	40.90	42.53	46.48	47.29
69	33.36	35.01	36.60	38.26	39.84	40.67	41.50	43.16	47.16	47.99
70	33.84	32.52	37.13	38.81	40.42	41.26	42.10	43.78	47.84	48.69
71	34.32	36.03	37.66	39.36	41.00	41.85	42.70	44.40	48.52	49.38
72	34.80	36.53	38.19	39.92	41.57	42.44	43.30	45.03	49.20	50.07
73	35.29	37.04	38.72	40.47	42.15	43.02	43.90	45.65	49.89	50.77
74	35.77	37.54	39.25	41.02	42.72	43.61	44.50	46.28	50.57	51.46
75	36.25	38.05	39.78	41.58	43.30	44.20	45.10	46.90	51.25	52.15
76	36.73	38.56	40.30	42.13	43.88	44.79	45.70	47.52	51.93	52.84
77	37.21	39.06	40.83	42.68	44.45	45.38	46.30	48.15	52.61	53.53
78	37.70	39.57	41.36	43.23	45.03	45.96	46.90	48.77	53.30	54.23
79	38.18	40.07	41.89	43.79	45.60	46.55	47.50	49.40	53.98	54.93

Cost of a hectolitre in francs.	41° or 17° Cartier.	43° or 17°½ Cartier.	45° or 18° Cartier.	47° or 18°½ Cartier.	49° or 19° Cartier.	50° or 19°¼ Cartier.	51° or 19°½ Cartier.	53° or 20° Cartier.	58° or 21°¾ Cartier.	59° or 22°¼ Cartier.
fr.	fr.	fr.	fr.	fr.	fr.	fr.	fr.	fr.	fr.	fr.
80	38.66	40.58	42.42	44.34	46.18	47.14	48.10	50.02	54.66	55.63
81	39.14	41.09	42.95	44.89	46.76	47.73	48.70	50.64	55.34	56.32
82	39.62	41.59	43.48	45.45	47.33	48.32	49.30	51.27	56.02	57.01
83	40.11	42.10	44 01	46.00	47.91	48.90	49.90	51.89	56.71	57.71
84	40.59	42.60	44.54	46.55	48.48	49.49	50.50	52.52	57.39	58.40
85	41.07	43.11	45.07	47.11	49.06	50.08	51.10	53.14	58.07	59.10
86	41.55	43.62	45.59	47.66	49.64	50.67	51.70	53.76	58.75	59.79
87	42.03	44.12	46.12	48.21	50.21	51.26	52.30	54.39	59.43	60.49
88	42.52	44.63	46.65	48.76	50.79	51 84	52.90	55.01	60.12	61.19
89	43.00	45.13	47.18	49.32	51.36	52.43	53.50	55.64	60.79	61.88
90	43.48	45.64	47.71	49.87	51.94	53.02	54.10	56.26	61.48	62.57
91	43.96	46.15	48.24	50.42	52.52	53.61	54.70	56.88	62.16	63.26
92	44.44	46.65	48.77	50.98	53.09	54.20	55.30	57.51	62.84	63.95
93	44.93	47.16	49.30	51.53	53.67	54.78	55.90	58.13	63.53	64.73
94	45.41	47.66	49.83	52.08	54.24	55.37	56.50	58.76	64.21	65.42
95	45.89	48.17	50.36	52.64	54.82	55.96	57.10	59.38	64.89	66.13
96	46.37	48.68	50.88	53.19	55.40	56.55	57.70	60.00	65.57	66.84
97	46.85	49.18	51.41	53.74	55.97	57.14	58.30	60.63	66.25	67.52
98	47.34	49.69	51.94	54.29	56.55	57.72	58.90	61.25	66.94	68.20
99	47.82	50.19	52.47	54.85	57.12	58.31	59.50	61.88	67.62	68.90
100	48.30	50.70	53.00	55.40	57.70	58.90	60.10	62.50	68.30	69.60

Receipts for Aging Brandies and Other Spirits; for Improving them, and for Imitating the Aroma and Flavor of Different Growths.

Everybody knows that the best distilled new brandies always retain a sharpness, which causes them to be recognized at once, and that they are so much better as they become older. It is known, too, that they equally preserve the taste of the soil, or the peculiar flavor which distinguishes the wines from which they were obtained, and that to correct this sharpness, to age, and to imitate the aroma of different growths, certain precautions are to be used. We shall indicate below, those which are most certain of success.

Cutting or Mixing Common Brandies (Coupage).

In the brandy trade, they generally employ the spirits (trois-six) of Montpellier, of beet, molasses, or grain, for the manufacture of common brandies, which are then labelled brandy of *Montpellier*, *Armagnac*, &c., according

as the spirits have been mixed with *low wines* prepared for the purpose, or with some other preparation. The mixing (or *cutting*) with pure water always produces a brandy which is harsh and biting, without perfume or delicacy.

The following are the different methods of preparing common brandies:—

First Process.—This consists in reducing the spirit to the requisite degree, and adding to the mixture 3 litres of *cane molasses* for each hectolitre of brandy. The molasses should be previously well mixed in the water intended for the cutting, with a sufficient quantity of good caramel to produce a golden yellow tint. When the mixing is finished, two centilitres of *volatile alcali* (*aqua ammonia*) is to be added, and the whole vigorously stirred with a rummaging stick.

Second Process.—In this process the molasses is replaced by an equal quantity of *syrup of raisins*, and proceed as above.

Third Process.—This is the same as the last, except that, in addition to the *syrup of raisins*, two per cent. of common rum are added to the brandy.

Imitation of Brandies.

Process for Imitating the Brandy of Armagnac.—To each hectolitre of trois-six, reduced, is added the following mixture:—

Infusion of walnut bulls	1 litre.
Infusion of the hulls of bitter almonds .	2 litres.
Syrup of raisins	3 "

These quantities may be increased or diminished, according to the quality of the brandy wanted, and the character of the infusion and syrups employed.

Another Process for Imitating the Brandy of Armagnac.—To obtain 100 litres of this imitation, at 49 degrees, take:—

Alcohol of good flavor, at 85° .	56	litres.
Common rum	2	"
Water	40	"
Syrup of raisins at 36° . . .	2	"
Dried liquorice root . . .	500	grammes.
Black tea	60	"
Cream of tartar (bitartrate of potash)	2	"
Boracic acid	1	gramme.

Bruise the liquorice root, and boil it with half the water intended for the reduction, in order to extract all its saccharine principles; then infuse the tea separately, in a hermetically closed vessel, with ten litres of boiling water, then dissolve the cream of tartar and boracic acid in two litres of hot water. When all of these preparations have become cold, pass the infusions of tea and liquorice root through a hair cloth, and mix the whole together with the alcohol, rum, syrup of raisins, and enough pure water to make up 100 litres. Color the mixture with a sufficient quantity of good caramel.

Method of Imitating the Brandy of Saintonge.—The following is the process for 100 litres of trois-six reduced to 50 degrees, to which, at the time of the reduction, have been added three per cent. of syrup of raisins, at 36° Baumé:—

Infuse five grammes of powdered Florentine iris root for fifteen days, in two litres of rum, with the rind of two sweet oranges; five grammes of the best Mexican vanilla, and five grammes of angelica seed; then, at the time of the reduction, make separate infusions in a litre of boiling water, of 30 grammes of imperial tea, and 30 grammes of the flowers of the linden; then the three infusions (rum, tea, and linden flowers), pressed and filtered, are to be added to the 100 litres of brandy rummaged thoroughly, and colored, if necessary.

Method of Imitating Cognac Brandy.—Of all brandies, Cognac is the most difficult to imitate, and among the numerous preparations used for attaining this end, we have seen very few which so nearly approach success as the following:—

Alcohol at 85° (well flavored) . .	54	litres.
Rum of good quality	2	"
Syrup of raisins	3	"
Infusion of green walnut hulls . .	2	"
Infusion of the shells of bitter almonds.	2	"
Catechu in powder	15	grammes.
Balsam of Tolu	6	"
Pure water	27	litres.
Product . .	100	litres.

Dissolve the catechu and balsam of Tolu together in a litre of alcohol at 85°, and pour this solution into the 53 litres of alcohol before adding the water; mix all the liquids together, rummage thoroughly, and then color with caramel of the best quality.

Remarks.—The quality of the water and caramel in the manufacture of these brandies is of the highest importance, and they should have bestowed on them the most scrupulous attention. We shall, in the second part of this book, point out the inconvenience which results from using these liquids if they are spoiled or badly prepared. Rain water is to be preferred.

The object of using the syrup of raisins or molasses and liquorice root is to soften and impart a smoothness to the brandy; the addition of the rum, infusion of the hulls of bitter almonds, of the tea, catechu, and balsam of Tolu is to impart bouquet, delicacy, and aroma. The infusion of walnut hulls gives the flavor of age, the cream of tartar and boracic make a bead on brandy at 45°; the liquorice root also has the same property.

In the reduction of trois-six in which much water is employed, the syrup of raisins, by reason of the tartar it contains, has the additional advantage of precipitating all the lime and its various salts that may be held in solution.

It is indispensable to use the volatile alkali in the proportion of 2 centilitres (about 20 grammes) to the hectolitre when the brandy is sharp, or when it contains an acid; and, in any event, whatever be the nature of the brandy, this small quantity of the alkali can do no pos-

sible injury either to the quality of the spirits or to the health of the consumer.

Another Method of Imitating Cognac Brandy.—The following receipt is used by one of the largest houses in the spirit trade in Paris:—

Rum of good quality	2	litres.
Liquorice root	500	grammes.
Roman chamomile . . .	125	"
Vanilla	10	"
Brown sugar	1	kilogramme.
Good flavored alcohol at 85° .	68	litres.
Rain water from the cistern . .	30	"
Product 100 litres at 58°.		

Bruise the liquorice root and boil it in a portion of the water intended for the mixture, then make hot infusions (separately) of the chamomile and vanilla each, in a hermetically closed vessel. When cold pass all these infusions through a cloth filter, add them to the trois-six and the remainder of the water in which the sugar has in the mean time been dissolved.

Improving Brandies.

Generally the genuine new brandies of Montpellier, Armagnac, Cognac, and other districts, are improved in quality by adding to them 15 grammes of sugar candy, or 3 centilitres of the syrup of raisins to the litre, which removes their sharpness and renders them smoother and more agreeable.

Independently of this addition of sugar, the aroma and flavor of the brandies of Armagnac may be considerably augmented by the addition of a litre of the infusion of green walnut hulls and a litre of the infusion of the hulls of bitter almonds, or in the absence of these two infusions, of two litres of rum to each hectolitre of brandy.

The flavor, the aroma, and the age of the brandies of Cognac, Saint Jean d'Angely, Saintonge, etc., may also be increased by the addition of various substances. The following is a receipt for one hectolitre of brandy:—

Old rum	2 litres.
Old kirsch	1.75 "
Infusion of green walnut hulls .	75 centilitres.
Syrup of raisins	2 litres.

Low Wines prepared for reducing Spirits.—In Angoumois, Saintonge, and Aunis, the dealers in spirits are in the habit of reducing their brandies with low wines prepared especially for giving them age; this custom is an excellent one, and we cannot recommend it too highly. The following is the method of proceeding:—

A certain quantity of rain water is collected and allowed to stand for several days in order that it may deposit all the foreign substances that may have been suspended in it. After a sufficient rest, the clear portion is drawn off and stowed in pipes or barrels where 10 or 12 per cent. of brandy at 58° or spirit at 85° is added to preserve it. When this water so prepared has been kept for six or eight months in the casks it has acquired indisputable merit for the softness and qualities of age it communicates to brandies. There are some dealers who consider that the low wines, when three or four years old, are quite equal in value to new Cognacs.

There is still another method of preparing the low wines intended for reducing spirits which, independently of the smoothness and age, impart a perfume to those brandies which lack it. It is as follows:—

An empty barrel of any size is set on end; we introduce into it about ten kilogrammes to the hectolitre of its capacity, of the chips, shavings and sawdust of the *white oak*, which are left from the manufacture of the barrels for Cognac brandy. The cask is then filled with water to disgorge the wood. After six or eight days' infusion, this water, which is not used, is drawn off, and the cask is filled with rain-water, to which has been added a tenth of spirit or brandy.

This water by age improves in color and quality; mixed with brandies in proper proportions, it gives them an excellent bouquet.

Extract or Essence of Cognac.—The spirits of different countries and of various kinds, previously softened

by the addition of sugar-candy or the syrup of raisins, harmonize very well with the preparation of which the following is the receipt for a hectolitre of spirits:—

Sassafras wood	10	grammes.
Balsam of Tolu	10	"
Catechu	100	"
Essence of bitter almonds	1	"
Vanilla	5	"
Well flavored alcohol, at 85°	1	litre.

Triturate the vanilla in 125 grammes of brown sugar. Macerate the whole for eight days, shaking frequently and thoroughly; then, after a rest of twenty-four hours, draw off the clear portion, and pour this extract into the spirit to be improved, taking care to rummage the mixture well so as to incorporate the elements thoroughly.

Improvement of Different Spirits.

Rum, kirsch, gin, absinthe Swiss or any other spirit, when newly made, always possesses, like spirits in general, a harshness and very disagreeable pungency; this imperfection may be corrected by adding to them 15 grammes of white sugar or sugar-candy to the litre of spirits.

New Method of Distilling Wines Practised in the Charentes.

For some years a number of distillers in Charentes introduced into their wines (as is done in distilling kirsch) spirits of wine, beet, rice, sorghum, &c., before submitting them to distillation, in order to produce a greater quantity of Cognac brandy.

The increase of the product, by a reasonable addition of foreign spirit to the wine distilled, is quite important, since it may, according to the season, double the quantity produced by the distillation of the wine, without the addition of any alcohol.

The object of this addition of spirit is to increase the profit by utilizing the superabundance or excess of organic acids which exists in the wine, and the greater portion of which is lost by the old method, since it is found in the spent wash in quite considerable quantity.

It appears that it is during the distillation, and under the influence of heat, that brandy acquires the inimitable flavor and aroma which constitute its merit, and which are so highly appreciated. In fact, during this operation, reactions take place between the acids just mentioned and the alcohol, which produce the peculiar ethers which give to Cognac its flavor and perfume.

It is a fact worthy of note, that the brandy obtained in consequence of the addition of a spirit foreign to the wine, in limited proportions, cannot be distinguished from the brandy resulting from the natural wine by itself; that is to say, without this addition. Finally, brandy resulting from this new method defies all methods of investigation. We may suspect the mixture, and even know of its existence, but we cannot furnish the proof; neither the most skilful and practised taste, nor the persevering researches of the most skilful and learned chemists, have been able to detect it. M. Payen himself acknowledged some time since that, in the actual state of the science, the discovery of this mixture presented insurmountable obstacles.

Now this question may be raised. Although the addition of a determinate quantity of alcohol to the wine does not change the characteristic properties of the brandy, does it not constitute a fraud or an alteration, and should it not be so considered? This question has been warmly discussed by the proprietors of large vineyards in Charentes, various dealers, and many eminent chemists. Messrs. Dampierre, Barral, Payen, and Sanson, have taken a very large and active part in the discussion. The last, among others, recently presented a paper on the subject to the Academy of Sciences and the Central Agricultural Society, well worthy the attention of those distinguished associations, in which he concludes that, in a scientific point of view, we may consider this process for manufacturing brandies both rational and lawful, since it consists in the augmentation of the alcoholic richness of the wines of the country, and consequently their productiveness.

Without pronouncing a decided opinion on the matter

under discussion, we think that we may be permitted to say that it is always right and proper for producers and dealers, who sell these mixed brandies, to be careful that their composition and origin are made known, and that they should not be sold as pure Cognacs. To act on any other principle, would be a culpable offence which the honest trade should condemn, and which should bring the offender under the notice of the correctional police, because the seller *has deceived the buyer as to the nature of his merchandise.*

PART II.

DISTILLATION OF PERFUMED WATERS, LIQUEURS, ESSENCES, ETC.

HISTORY OF LIQUEURS.

The ancients were acquainted with, and made great use of liqueurs, which, at first, were used as medicines, or as corroborants. Afterwards, they were found capable of stimulating the appetite, and assisting digestion. These liqueurs had for their basis simply the must of the grape or wine, which was aromatized according to the peculiar properties attributed to each of the liqueurs.

Hippocrates, the father of medicine, was the inventor of the first aromatic liqueur, the use of which has spread to almost all nations, and which has always borne the name *Hippocras.* It was, at first, composed of wine, cinnamon, and honey; but, in the course of time, it was improved, particularly by Alexis, of Peidmont. This mixture, so much vaunted by our ancient romancists, was, for a long time, very fashionable; it was served on all great occasions of feasting. Louis XIV. was very fond of it; the city of Paris presented him, every year, with a certain number of bottles of it, and his cooks set themselves up as rivals of the distillers of the capital in the manufacture. There were still some remains of this ancient custom in the reign of Louis XV.

Pliny, Galien, and Dioscorides soon followed the example of Hippocrates; they employed wines in which they digested hyssop, absinthe, calamus, &c. &c. The Romance of Floremond alludes to them under the general name of "*wine of herbs,*" and it is spoken of in the tenth, eleventh, and twelfth centuries. All that remains

of these is the wine of absinthe, which is called, in Italy, *Vermut*, and is an excellent stomachic. According to Pliny, the wines, to which were added the juices of certain fruits, were known to the Gauls, and they were in the habit of introducing into their new wines the buds and berries of the mastich, in order to render them more pleasant to the taste. Pliny also says, that wines containing absinthe prevent sea-sickness. He makes mention of the games celebrated at the capitol, where, among other prizes, they gave to the conqueror a drink mixed with absinthe, as a fountain of health.

Arnault de Villeneuve and Raymond Sulle invented the first known liqueur based on alcohol—they called it *eau divine et admirable* (divine and admirable water); this was simply brandy mixed with sugar; it was then considered as a medicine, and for many centuries it was so regarded. Much later, the *eau divine* was perfumed with the lemon, the rose, and orange flowers. The convent of Saint Sacrement, rue Saint Louis, au Marais, in Paris, had, in 1760, the reputation of preparing eau divine in superior style, producing it of extreme delicacy of flavor.

About the year 1520, Theophrastus Paracelsus, professor of chemistry at Basle, invented many liqueurs, which he called the grand arcanum, great and small circulation, and, among others, the famous *elixir proprietatis*.

Brouat, a physician, in 1636, conceived the idea of extracting the essential oils from drugs by means of brandy, with the intention of compounding liqueurs which were generally administered as cordial draughts. The following quotations from Brouat himself, on the subject of aromatic liqueurs, and, more particularly, the brandy of the ancients, are very curious, and the energy of his style is odd enough to justify the belief that our readers will not be displeased at finding it presented to them.

"Would you then adorn this heaven (brandy) with all-powerful stars? Extract from it tinctures and essences of all things that are fitting for the general preservation of a long life, or rather for the special cure of every disease.

"For the preservation of the general health, you shall take the corroborants of the noble parts, as for the *brain*, the *heart*, the *liver*, the *stomach*, the *lungs*, the *kidneys*, the *spleen*, or others, and you shall not have need for a great mass to appropriate to each; but it will be enough to select that which will possess the greatest virtue; as for the HEART, you shall take *saffron* and *mace;* for the BRAIN, *musc* and prepared *vitriol;* for the NERVES and HEAD, *lavender*, *sage*, and *rosemary;* for the LIVER, *cocklebur* and *aperient roots;* for the KIDNEYS, *lapis nephriticus;* for the SPLEEN, *tamarinds;* for the TESTES, *figs* and *orchis mascula;* for the VEINS, *angelica;* for the LUNGS, *liquorice, argillaceous earth.*

"For the *simplest* medicaments are the best, and the great number or crowding of remedies into a body never produces either a good or laudable effect, and nature acts more promptly on the reception of a few than at the importunity of many, which rather produce a surcharge and hindrance."

Brandy (*eau-de-vie*), employed at the beginning of the thirteenth century as a medicine, passed insensibly to the table, and soon became the favorite of the people. Then the Italians more than any other people set themselves to making it agreeable to the palate. They discovered the means of giving it a higher value for the use of the wealthy classes. They called these new drinks *liquori*, and they exported them to foreign countries. The French first adopted the use of them in 1532 at the time of the marriage of Henry II., then Duke of Orleans, to Catherine de Medicis. This court attracted into France a great number of Italians, who brought along with them the delicate dishes used in their own country, and gave instruction as to the methods of preparing them. They were the first who manufactured and sold fine liqueurs in Paris. The earliest among these was *rossoli*, in which the rose furnished the preponderating perfume. The precise etymology of this word *rossoli* cannot be given; it very soon, however, became general as applied to all cordials or *ratafias*. It

may be derived from the plant *ros solis* (*Drosera rotundifolia*), which among others enters into the composition of this liqueur. The rossoli called *populo* was highly esteemed during the reigns of Henry III. and Henry IV. The ratafias of cherries and violets, as well as many other liqueurs, were intended for the purpose of reviving the old age of the king, Louis XIV.

Finally, towards the beginning of the last century, while the distillers of Montpellier were exercising themselves in compounding the liqueur called *eau d'or* (water of gold), in allusion to the potable gold of the ancient chemists, the Americans produced the celebrated ratafia from *Cedrat*, which they called *crême des barbades*, Dalmatia introduced its *marasquin de zara*, Amsterdam its *curaçao*, while Bourdeaux acquired a world-wide reputation for its *anisette*. Garus, a physician, gave us the *elixir* which bears his name, Colladon of Geneva his *eau cordiale*, and Bouillerot invented *huile de Venus*.

Since liqueurs are so much varied, the diversity of names called for by the public has greatly increased in our day; so that the distillers have multiplied them on every side. Those of Paris, Villette, Lyons, Bordeaux, Limoges, Rouen, &c., rival each other in price and quality. At the present time the monks of the order of Saint-Bruno, who reside at the monastery *Grande Chartreuse* near Grenoble manufacture three elixirs; white, yellow, and green, which have a great reputation. The *liqueur hygiénique* of Raspail also enjoys a high degree of public favor.

A full description of the apparatus used in the various processes of distillation has been given in the earlier chapters of this book, and a repetition here will be unnecessary.

CHAPTER XII.

DISTILLATION.

As has been seen in the first part of this book, distillation is a chemical operation, the object of which is, to separate with the assistance of heat the lighter or more soluble parts of any substance by converting them into vapor, and then by the application of some colder body, removing the heat which was the means of producing the vapor, condensing them so as to collect them in a liquid form. The operation requires much care and skill.

The business of the *brewing distiller*, or the manufacturer of alcohol, consists in separating the spirituous parts from any liquid whatsoever, that has been previously subjected to the vinous or alcoholic fermentation.

The liquorist, on the other hand, never distils except for the purpose of obtaining the perfume of aromatic substances, either by means of water or alcohol; in a word, he aromatizes these liquids, and rarely distils water or alcohol separately.

The Laboratory, Store-rooms, Cellars, &c.

The laboratory of the liquorist should be of sufficient extent to enable him to carry on his operations with facility; the walls well constructed of good materials, vaulted or plastered; of sufficient height of pitch to prevent the flames, in case of fire, from reaching the ceiling. It should be well ventilated, lighted from above as much as possible, paved with gravel, or what is better still, with bricks or stone tiles.

It is of the greatest importance to have at hand a spring or well, which may furnish a sufficient supply of water. A great quantity is required for washing the vessels; more for cooling the stills, and in case of necessity,

to arrest fires which may occur in the establishment. For this purpose, a reservoir is indispensable; which should be large enough to contain all the water needed for a day's work, and even more. It should be filled every evening. The chimney should have a large and well-constructed flue. The breast of this chimney should be very broad, and have the form of a broad, open hood, under which should be placed the furnaces for the pans and stills.

The store-rooms for the liqueurs should, if possible, be on the same level as the laboratory. It is important that they should be dry. They should be paved or floored with pitch, and have a constant temperature of 12° or 15°.

The store-rooms for brandies and other spirits ought to have about the same temperature as for liqueurs. This is of great importance, because heat increases, while cold diminishes the body of liquids. This store-room should only be half lighted, and the floor sprinkled with saltpetre.

The cellars should be situated on the north side, and have a depth of five or six meters. The vault under the keystone should have a height of about four meters, and ought to be covered to the depth of a meter or a meter and a half with earth; for the deeper the cellar the better the vault. Its temperature should be maintained constantly at 10° or 12° Cent., and it is proper when the temperature exceeds this degree, to close a portion of the air holes (or ventilators), and when the temperature diminishes to open, without, however, reducing the temperature below 10° above zero.

The moisture should be constant without being too great; an excess causes the barrels and stoppers to mould, &c.; a deficiency of humidity causes the casks to dry, thereby causing loss of liquid. The reflection and direct light of the sun must be avoided, as it causes variations of temperature in the cellar, thereby affecting its character. The light should be very moderate. While too bright a light is drying, almost absolute darkness may and often is the occasion of an explosion, which may result in the bursting of the casks.

The cellars should be protected as much as possible from the jarring of passing vehicles, and the vicinity of forges where heavy hammers are used. Both excite in liquors as well as in wines oscillations, which cause them to deposit a residuum in casks or in bottles.

Perfect order and absolute neatness should prevail in all parts of the laboratory, the store-rooms, cellars, and in all the operations of the liquorist. Without order, the labor is confused and hindered at every turn; without cleanliness there can be no good products, for the very best materials will only yield the most inferior results; then in summer a swarm of flies will add to the annoyance. To avoid all inconveniences, it is necessary to assign to everything the place it should occupy habitually, and to wash and replace all utensils whenever they have been in use, and to scour all implements every evening that have been in use during the day; the stills should be examined frequently, to see if they require repairs or retinning; the whole laboratory should be washed every day, so as to remove all substances calculated to attract flies, or to engender filth, or to exhale unpleasant odors. The fuel, sugars, plants, and other ingredients, should be kept in very dry places, except mineral coal, which may be stored in the cellar.

Vessels and Utensils.

Having treated of the subject of stills, areometers and thermometers, in the preceding portion of this book, it remains for us to describe only the vessels and utensils which are required in fitting up the laboratory of a liquorist.

There must be many *pans* or basins of copper of different sizes (Fig. 4), as well for melting and clarifying sugar as for the preparation of syrups and preserved fruits, and other purposes. These pans should be broad rather than deep, so as to afford a greater surface for evaporation; the bottom should be convex, in order to present the largest surface to the action of the heat, and prevent the sugar or other substance from becoming impacted and being burned. The pans, intended for blanching and preserving fruits should, on the other hand, be flat at the

bottom, so that the fruits may not be crushed or bruised. Then come *filters* (Fig. 5): these should be of tinned

Fig. 4.

Pan.

copper of many sizes, furnished with covers and stopcocks, having small hooks within, arranged at different

Fig. 5.

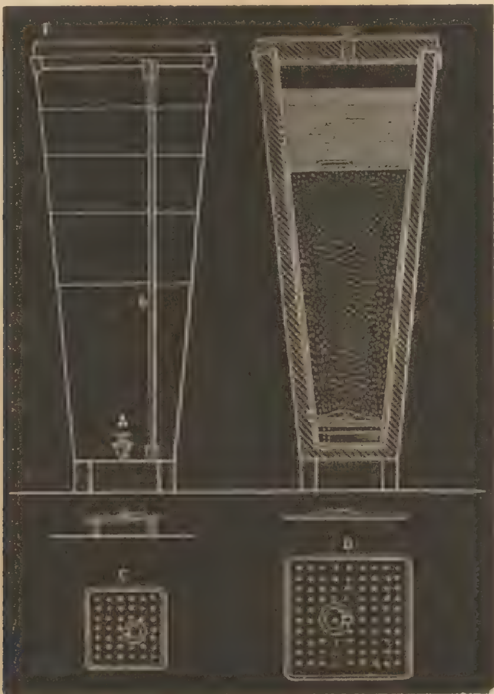
Filters, dippers, and dish.

distances for attaching the strainers. These filters, which resemble large, closed funnels, should be mounted on a frame of oak, under which is placed a vat lined with tinned copper, in order to catch any liquid which, by the inattention of the workmen, runs over the top of the vessel intended to receive it.

A number of *filters for decolorizing syrups*. This very simple filter consists of a box having the form of an inverted, truncated pyramid. This box is made of wood, lined within with tinned copper soldered at the angles; at the bottom, is a stopcock A, for drawing off the syrups; a

little above the bottom is a hole to receive a tube B, applied to the exterior of the filter to afford a means of escape for the air contained in the apparatus. Within these are two perforated diaphragms, also of tinned

Fig. 6.



Decolorizing filter.*

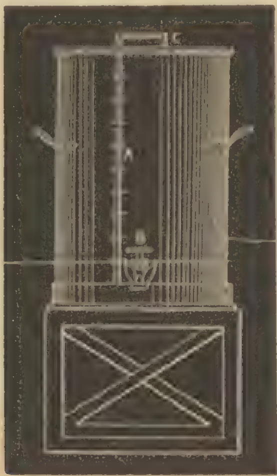
copper, one of which is larger than the other to adapt them to the form of the case, one being placed near the bottom, and the other fitting near the top. It is completed by the cover E, intended to prevent the contents from cooling too rapidly. We shall describe the manner of using the filter in the article on the *Clarification of Sugar*.

Cans (*conges*), of different sizes, for mixing liqueurs.

* This is also known as a "RECTIFIER" by the liquor dealers of the United States.—*Trans.*

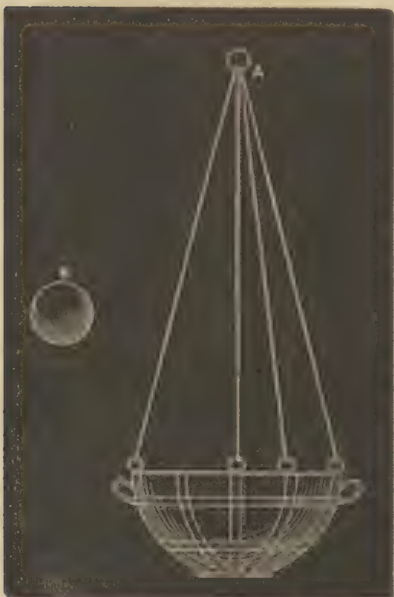
The can (Fig. 7) of the liquorist is made of copper, tinned within, having a graduated scale to indicate the quantity of liquid it contains, a stopcock B and cover C.

Fig. 7.



Graduated can of the liquorist.

Fig. 8.



Wooden bowl and iron ball.

A large *bowl* lined and bound with iron, having two handles and supported at a height of about one metre from the floor by cords A, attached to a strong hook in the ceiling

This bowl is set in motion by twisting the cords first in one direction and then in another, and by means of the iron ball B, which weighs 10 or 12 kilogrammes, serves for bruising almonds for orgeat syrup. There are many machines in Paris for the same purpose, but we are assured by our own experience that they are all inferior to this simple apparatus. We ought to say, however, that we have seen at Orleans a machine for crushing almonds, similar to a mustard mill, which produces excellent results. We shall describe it in speaking of syrup of orgeat.

Fig. 9.

Covered mortar.

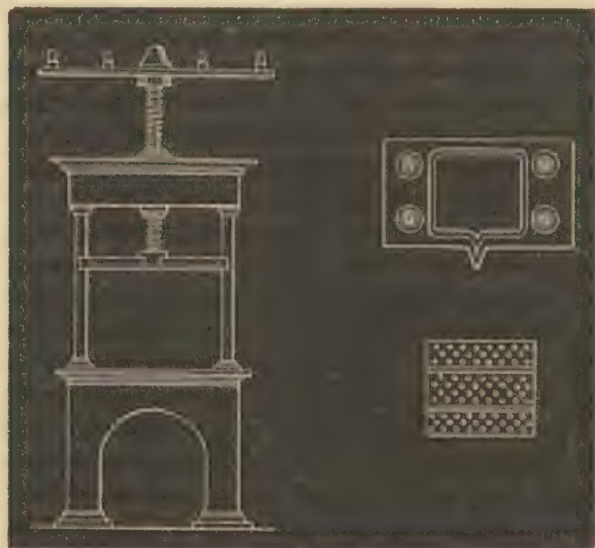
A *cylinder* or *roaster* for roasting coffee and cocoa, a *coffee mill*, a stone or marble mortar with a wooden pestle, and a small *brass* mortar.

A large *iron* mortar for bruising hard substances having a loose pocket-like cover of leather, which is attached to the top of the mortar by a hoop with a hole at the top, for the passage of the handle of the pestle.

Strainers of silk and *hair* for straining liquids, a *syphon* with a stopcock and a *liquor pump* of tin for transfering brandies and liqueurs into barrels, a small *syphon* of *glass* or *tin* for smaller operations, a *florentine receiver* of glass, funnels of tinned copper, glass and tin of various sizes; a *dipper* and its *dish*, both of which should be tinned, for pouring liquids on the filters and filling the *brocks* (metal jugs). The dipper should have a capacity of three litres and have a scale marked on its interior.

A *press* (Fig. 10) with its frame for expressing the juice from fruits and the marc of currants; an extra

Fig. 10.



Press.

bed is necessary for pressing the marc of orgeat. A large oak table for the general use of the laboratory; under which should be a large *drawer* containing plyers, nippers, sugar and fruit knives, graters, cork compressors, etc.

The liquorist should have, according to the importance of his establishment, a certain number of *hogsheads* and *barrels* of oak well bound with iron, having brass stopcocks, painted with oil-color, as much to protect from moisture and the boring of insects as to prevent evaporation through the pores of the wood. The paint is not a useless ornament. These vessels should stand on end upon trestles so as to occupy the least space.

The laboratory should be abundantly provided with flat *spatulas* of oak for stirring the mixtures, *sauce-pans* with a lip, and others, *skimmers*, *pipkins* and *crocks* of stone of different sizes, *brocks* of tin, copper and wood, *demijohns* covered with osier; *flasks*, *jars*, *long* and *short necked bottles* of glass, *glazed earthen pans*, *tubes* for examining and testing liqueurs and syrups, a tin box having many divisions, in which are kept the instrument for testing the specific gravity of liquids, *steel-yards*, *scales* and *weights*, and *tin measures* for liquids.

A large assortment of *strainers* and filtering *cloths* of different sizes is necessary. The filtering cloth (*chaussée*) is a sort of pocket of cloth or other woollen stuff, of conical form, used for filtering liqueurs. It is hooked inside of the copper filter. The strainer is a square piece of woollen cloth having a row of eyelets along its edge through which a cord is run. This is hung by means of small hooks in a square wooden frame for straining syrups.

The use of steam for heating *conserves* cannot be too highly recommended to the liquorist, whatever may be the extent of his business. The apparatus he should employ should consist of an upright oaken chest lined with zinc or copper (the latter is preferable), having a number of shelves of iron. These shelves are open, being composed of thin iron bars placed two fingers in width apart, and are for supporting the bottles and jars. The door is closed by means of two buttons or bolts, and has in the middle a glazed opening behind which a thermometer is hung in order to indicate the degree of heat within. At the bottom of the chest is a stopcock for drawing off the water condensed from the steam.

The steam is admitted from below by means of a pipe and stopcock, communicating with a small portable boiler, having a water and steam gauge and a safety valve like boilers of larger size.

Furnace.

After stills, the furnaces should attract the attention of the liquorist. On their proper construction depends very much the success of his operations. Every possible care should be given to their arrangement, for, independently of the matter of economizing fuel, they exercise great influence on the quality of the products.

A furnace consists, first, of the fireplace; second, the grate; third, the ash pit; fourth, the chimney.

The Fireplace.—The fireplace is the space between the bottom of the still or boiler and the grate, or the place in which the fuel is burned. The walls of the fireplace should be so arranged as to reflect the greatest possible quantity of heat. It is requisite, for attaining this end, that they should be comparatively restricted in their dimensions so that the bottom of the still may receive the full action of the fire, and that the flame and heated air may circulate freely beneath, before passing off by the sides. The dimensions of the fireplace should, therefore, be strictly proportioned to the size of the still and the character of the fuel to be employed. It should be so constructed that the flames, after having *licked* the bottom of the apparatus, may circulate freely around by means of a flue of special form, making several turns before reaching the chimney. By this arrangement the heat, which would otherwise escape, and be lost in the chimney, is utilized, the liquid is equally heated, and the smoke only escapes after having been deprived of a greater portion of its heat.

The door of the fireplace should fit as perfectly as possible, in order to prevent all access of atmospheric air, except through the openings into the ash pit. A complete closure of this opening is obtained by substituting for the door a round hole, stopped by a conical sheet-iron plug filled with sand or cinders.

The Grate.—The grate is the support for the fuel, and on which it is burned, by maintaining it in a suspended position, so that the air may have free access to it, thereby facilitating the regulation of the fire.

The bars of the grate should be movable, of cast iron, very strong, and straight; they should be supported firmly on bars of iron; because grates in a single piece, or fixed in a frame, are liable to be disarranged by warping, and are difficult to clean. The bars for burning wood should be placed horizontally, the cross section being a quarter circle, so that the coals may always fall to the middle of the grate, while for coal, the bars should be arranged horizontally, and on a level. The space between the bars, as well as their size and number, will depend on the dimensions of the furnace, and the character of the fuel.

Finally, the grate should be fixed in the fireplace under the anterior part of the still, so that this portion of it may receive the direct action of the fire, and, as the draught tends to send the flame and heat towards the chimney, the greatest possible effect is produced.

The Ash Pit.—The ash pit, besides the use which its name indicates, is principally intended to afford access for the air which serves to keep up the fire. Its dimensions are a matter of indifference, especially for wood; yet, it is necessary that it should have sufficient height and depth to contain all the ashes resulting from a day's work, without being crowded. The ash pit should be closed accurately by a sliding damper, by which the draught of the chimney may be regulated and the fire increased or lessened, as occasion may require. The use of coal renders the employment of this sliding damper indispensable.

The Chimney.—The chimney conveys the smoke and vapors arising from the combustion out of the laboratory; it causes, too, an upward draught, which constantly renews the air which finds admission through the ash pit; and this is the reason of the saying, that the taller the chimney, the better the draught. On this principle, the rapidity of the combustion, and the intensity of the

heat, will be in direct proportion to the height of the chimney.

The furnace should be constructed of smooth brick of good quality—those called *refractory* (*fire brick*) should have the preference; they are laid in a mortar made of clay and sand. This method of construction presents the advantages of acquiring greater solidity under the action of the fire, and of preserving a greater quantity of heat. The furnace should be faced on the exterior with pressed brick, and bound with iron. The height should not exceed 85 or 90 centimeters, in order that the stills may be luted without the necessity of getting on the brickwork, and that the pans of syrups and fruits may be handled with more facility.

On account of their importance, furnaces ought to be built by skilful and experienced men, who are perfectly acquainted with the subject of heat and its applications.

CHAPTER XIII.

FUEL.

For purposes of distillation and the other operations of the liquorist, heat is produced by the combustion of different articles of fuel, as wood, coal, and sometimes coke. As for charcoal and turf, they are employed only in those localities where it is difficult to procure the three first named, either on account of their scarcity or high price. The selection and use of these different kinds of fuel involve important questions of economy. That should be adopted, the price being the same, which will produce the most intense and lasting heat.

Heating by means of wood is not to be preferred, nor is it the least expensive. The heat produced by this fuel is far inferior to that from coal. The former unquestionably takes fire more readily, and produces a greater amount of flame, but the fire is not so easy of

control as that made with coal; nevertheless, there are some countries where wood is sold at a very low price, while, on the contrary, coal is very dear. We indicate the woods to which we would give the preference:—

1. Oak.	3. Hornbeam.*
2. Beech.	4. Elm.

Fire wood is found in the market of two sorts, cord wood and raft wood.

Cord wood is that which has been transported on wagons or boats from the forest to the place of consumption. This is the best. Raft wood is floated in rafts on navigable streams, from which circumstance it has its name. It is inferior to the former.

It is to be observed that hard wood which has been protected from the prolonged action of water is the best for heating purposes; round sticks are better than split pieces, which are only used for kindling.† This results in economy of fuel and regularity of heating.

Coal, or mineral coal, is of all fuels the most valuable, and most abundant; it presents the greatest advantages on account of its low price when compared with the amount of heat it produces. All industrial pursuits depend on this primary substance, as railroads, navigation, illumination, the manufacturing of iron, woollens, cotton, &c., for their very existence. Blot out her coal fields and England would become a wilderness.

Coke is *charred mineral coal*, as the residuum of the gas-works; it produces a very intense heat and leaves very little ash; it may replace wood-charcoal advantageously.

Charcoal is the residuum of all kinds of wood which have been deprived of all their volatile principles by the action of fire. It is black, brittle, sonorous, and of little solidity; it burns readily and produces a very great

* *Hickory and ash*, which are among the best of American firewoods, appear to be unknown for such uses in France.—*Translator.*

† The reader must remember that this is in France, where timber is converted to all manner of uses, and none but such as is fit for nothing else goes into the fire.—*Translator.*

quantity of heat; that which is compact and heavy should be preferred to that which is light.

Turf is the result of a partial decomposition of certain plants under water; it is brown or almost black; it burns with difficulty at first, but when once on fire, the combustion progresses very well; it produces little flame and yields a gentle heat, but emits a very unpleasant odor.

Application of Heat.

Heat is the principal agent of distillation; it is an interesting subject to examine and ascertain the laws according to which caloric is transmitted to and through bodies.

The name *caloric* is given to the fluid which constitutes the principle of heat; in other words, heat is the effect, and caloric the cause.

Caloric is an imponderable fluid, like light, distributed throughout nature; we become conscious of its presence through the sensation of heat which is impressed on our organs of sense; invisible, eminently elastic, it tends to a state of equilibrium in all bodies, penetrating them more or less easily, expanding them, decomposing, causing them to pass from the solid state to that of a liquid, and from a liquid to a gas, and on abstracting it from these substances they are reduced from a gas to a liquid, and from that to a solid; and finally, it has the power of combining with each in a different proportion, to bring them to the same temperature.

Those substances which heat penetrates easily are called *good conductors;* they are arranged in the order of their conductibility; silver, gold, copper, platina, iron, zinc, steel, tin, and lead.

Substances which heat penetrates with difficulty are called *bad conductors;* gases, liquids, porcelain, pottery, are not as good conductors as the metals named above; charcoal, dried wood, and glass are almost without capacity for conduction.

To explain more clearly the effects of caloric, we cite

some examples: mercury in its natural state is a fluid; if it is heated in a retort, the caloric accumulates in it, and the mercury is evaporated in the form of a gas; if it is deprived of a sufficient amount of its caloric by artificial cold, it becomes a solid. It is by these means that water assumes its three forms—liquid, solid, and gaseous. Nevertheless, the effects of caloric are not always as marked, all substances not having the same affinity for it. Thus, a piece of charcoal burning at one end may be held by the other end without inflicting any pain, while it would be impossible to hold in the hand a piece of copper or iron of the same dimensions, if heated to redness at the other extremity. It is, then, on this principle that alcohol boils and is converted into vapor at a lower temperature than that required for water.

The following table indicates the boiling points Cent. of different liquids, and although given in another part of this book is repeated here on account of its peculiar value to the liquorist:—

Sulphuric ether	35°.5
Liquid ammonia	60°.2
Pure alcohol	78°.4
Alcohol (90°)	80°.1
Alcohol (85°)	81°.1
Alcohol (59°)	85°.8
Alcohol (45°)	88°.9
Pure water	100°
Syrup of sugar	105°
Saturated solution of common salt	106°
Saturated solution of nitre	114°
Saturated solution of carbonate of potash	135°
Spirits of turpentine	155°
Sulphuric acid	305°
Linseed oil	315°
Mercury	350°

Caloric by its accumulation in, or interposition between the molecules of different substances, causes them to undergo a very variable degree of expansion. Its effects may be observed by the changes which take place in the thermometer. We have said, too, that substances tend to assume a state of equilibrium in regard to heat, hence

the sensations of heat and cold. According to this principle, we may understand that heat passes from one body to another by points of contact; this is the reason that well polished marble always feels cold; for the points of contact being greatly multiplied, a quantity of caloric is abstracted from the hand in proportion to the surface touched.

It may be conceived for the same reason, that in subjecting a liquid in a boiler to the action of caloric, it will be heated more rapidly when the boiler presents a greater number of points of attack to the heat arising from the fuel, and that the boiler should be constructed of some material that is a good conductor of heat. This is the reason why a boiler should be broad and shallow, if a prompt vaporization of the liquid it contains is desired.

Of the many means of producing heat, combustion is the most common and most useful. It is produced by one or other of the fuels to which we have alluded. It is by the assistance of the various parts which constitute the furnace that this combustion is effected, and the heat is applied to the different substances which it is desired to heat.

Having come to the amount of heat which is requisite for the operations of the liquorist, we may again remark, that water requires a greater quantity of heat than alcohol to boil and våporize it; the heating and vaporization of liquids are always in proportion to the heating surface; a mixture of alcohol and water will require for heating it the average of the amount of heat required for the two taken separately, that is to say, the boiling point of alcohol being 78°, and that of water 100°, that of the mixture consisting of equal parts of each will be 89°.*

One of the essential conditions of the application of heat is to produce it in the greatest quantity and at the least possible expense. It is manifest that distillation

* Two liquids of different boiling points, and which do not combine in solution, as water and benzole, water and oil of cloves, &c., will boil at a lower temperature than either alone. This explains why a liquid having a higher boiling point than water is converted into vapor by the injection of steam.—*Kundt in Puggendorf's "Annalen.'*

by the naked fire presents some inconveniences; so, large establishments ought unquestionably to employ steam for all operations having reference to the manufacture of liqueurs, syrups, and conserves; by it they will obtain products of superior quality and an economy of fuel which may be safely estimated at more than half the cost of heating; the breakages, too, which ordinarily take place when they are put over the fire in a pan of water are all avoided. We may affirm that under ordinary circumstances, no vessel containing any conserve whatever will be broken when heated by steam.

Many wholesale liquorists have their establishments arranged according to the principles we have herein set forth.

Plate IX. represents a liquorist's laboratory arranged according to the modern style and heated by steam.

Fig. 1.—Steam boiler.

A. Steam cock for regulating the supply of steam.

B. Copper pipe for conveying steam to the distillatory and other apparatus.

C. Cocks for admitting steam to the different pieces of apparatus.

Figs. 2 and 3.—Still with goose-neck receiving steam in a double bottom.

A. Strong table or oak trestle to support the stills.

Fig. 4.—Small goose-neck still complete in all its parts placed on a furnace and heated by a naked fire.

Fig. 5.—Cooler of copper containing the three coils of the above stills.

A. Receivers.

Fig. 6.—Turk's head still with all its parts; it stands on a furnace and is heated by the naked fire.

Figs. 7 and 8.—Copper pans receiving steam in double bottom.

A. Strong oak table or trestle supporting the pans.

Fig. 9.—Small copper pan for small operations, on a furnace heated by a naked fire.

Figs. 10 and 11.—Copper skimmers.

Fig. 12.—Oaken chest with two compartments, lined with sheet copper or zinc, and intended for the reception of the different conserves intended to be heated by steam.

Fig. 13.—Copper filters with covers for filtèring liqueurs, syrups, &c.

A. Brocks or metal jugs of tin or copper, of a capacity of 15 litres.

B. Table or trestle of oak to support the filters, with a trough beneath lined with copper to catch any liquid that may flow over the top of the vessels during the filtration.

Figs. 14 and 15.—Copper cans tinned inside for containing the liqueurs intended for feeding the filters.

Fig. 16.—Wooden shelf or dresser for different implements.

A. Copper bottles tinned inside, and of different sizes.

B. Copper pans for various purposes.

Fig. 17.—Another dresser also intended for various articles.

A. Pourers or pans with a spout or lip.

B. Brocks or jugs of copper tinned inside, and of different sizes.

C. Dipper and its dish; the two implements are of copper tinned inside and out; the former contains exactly three litres, and has a graduated scale inside, divided into three parts.

CHAPTER XIV.

DISTILLATION AND RECTIFICATION.

Distillation as Applied to Liqueurs.

THE liquorist, after carefully cleansing all the parts of his still, assures himself that no flavor remains; it is all important that the coil should be well rinsed with hot water, as much to remove the odors of the preceding distillation as to be assured that the convolutions are all open, for it may happen by some unforeseen accident that the coils may be closed, in which event an explosion would be inevitable. It must be observed that if this cleansing is done without first emptying the tub which

contains the coil, the operation will be of no avail, inasmuch as the hot water will be chilled in its course through the convolutions of the coil, and the flavor of the preceding distillation will not be removed as desired.

When the distillation is to be conducted over the *naked fire* the still is to be placed on the furnace with the open grating fixed in its place so as to prevent the materials from imparting a bad flavor by attaching themselves to the still and being burned. If the plants distilled are dried, care should be taken that they be not employed in too large a quantity; the heat and the liquid will cause them to swell, and it may happen that the luting will be disarranged, thereby causing an escape of liquid and perhaps a fire. To obviate this inconvenience, we should advise that the plants be cut in small pieces; this will cause them to occupy less space in the still, or water bath, and give better opportunity for them to absorb the liquid. It is important that the boiler of the still should be filled only to about two-thirds with liquid; the cap is then adjusted to its place and attached to the coil, the tub or vat containing the latter being previously filled with cold water. At the extremity of the coil must be placed a receiver to catch the liquid as it distills over during the course of the operation. The socket joint of the boiler and cap must be absolutely closed to prevent the escape of vapor; all the joints must be well paid over with a strong paste made of flour and water. The joints, after being covered with this paste, should have a layer of strong paper or of cloth bands applied to them; these bands are about the width of two fingers, and should be covered with paste on both sides, and should be bound over the already luted joints of the still, so that they shall cover them completely and closely.

When matters have been thus arranged the fire is kindled under the still, care being had that it is not pushed too much, especially at the beginning of the distillation; it is then gradually increased, and as occasion may require; when the first drops of liquid begin to flow, the fire should be moderated so that the vapors

may have time to condense and the chance of an explosion be prevented.

The distillation should be conducted so that the liquid may flow uniformly and equally. This result is obtained by an intelligent management of the fire, the variations in the stream being regulated by increasing or diminishing the amount of heat applied to the still. The operation is properly conducted when an average stream is maintained, for if we distill only by drops, the water or spirit obtained will be but slightly charged with the aromatic principle; if the fire is pushed too rapidly, it will cause the *feints* to rise with the water or spirit and volatile oil so as to render the liquid objectionable and give it an *empyreumatic* flavor. It frequently happens, too, that by a sort of explosive start, the liquid in the still passes over unchanged, carrying with it the substances intended to aromatize it.

The water of the cooler in which the coil is contained should be changed frequently; for the vapors which pass into the interior of the coil are condensed by constantly traversing new strata of cold water; and if this operation is neglected, the water, by becoming heated, will be the means of imparting an empyreumatic odor to the liquid. It must be observed during winter when it is very cold, that the cooler should be emptied after the day's work; the expansion of the water in the act of freezing may burst the vessel, or cause some injury to the convolutions of the coil.

The still should never be left, especially when distilling spirits, because spirituous vapors are much more liable to escape than water, and it may happen that the liquid may find a means of exit at the joints and spread over the surface of the furnace, or by running down the boiler come in contact with the fire. In this case the fire must be promptly extinguished by throwing water into the fireplace as well as on top of the furnace; the joints must be covered with wet cloths; the operator taking care when he approaches for this purpose to have his mouth and nose covered also with a wet cloth, for it is highly dangerous to breathe these inflamed vapors.

If it should happen that one should be covered with

inflamed spirits, he should be immediately covered with a wet cloth, which should be kept always ready and at hand; in default of this, he should throw himself flat on the floor, with his face to the ground, and call for help.

It frequently happens that persons covered with burning spirit run as they call for assistance. The flames are increased by the current of air caused by the running and occasion burns which are most generally fatal. La Villette, where there are a great many ignorant distillers, has been the scene of many accidents of this kind.

Distillation over the naked fire has the advantage of progressing with greater promptness, but it has in many cases the disadvantage of altering the product more or less decidedly; this results from the unequal distribution of the heat. It frequently happens that the liquid is dried and burned at the upper portions of the boiler, or rather that some of the solid particles of the materials subjected to the distillation may come in contact with the sides of the boiler and facilitate the accumulation of heat at this point by preventing the contact of the liquid which would keep it down.

Distillation in the *water bath* is conducted as follows: The *boiler* is placed on the furnace (the grating which was used when distilling with the *naked fire* having been removed) and half filled with water; the *water bath* is now fixed in its place, care being taken to observe that the water in the boiler does not rise higher than five centimeters below the neck. The *water bath* containing the liquid and other substances is then fixed in the boiler covered with the cap, which is to be attached to the coil; all the joints are to be luted and the fire kindled. The operation is conducted in all respects just as with the naked fire.

The distillation with the *water bath* does not require so much care as that with the *naked fire*, but it is necessary to take precautions to have the water in the cooler frequently renewed and to run off no more of the liquid than is proper.

By distillation in the water bath purer and lighter products are obtained; that is, the spirits are stronger in degree, while the perfume is more delicate and they have no empyreumatic flavor.

The water bath enables us also to avoid the destructive action of heat on the liquid and other substances distilled. It is always advantageous to the quality of the product, that the degree of heat at which the liquid to be distilled will boil, may be less than that of the auxiliary liquid contained in the boiler or outer vessel. For example, it is desired to obtain an aromatic water by means of the water bath; the transmission of the heat acting on liquids of the same degree will be slow and insufficient to cause a proper amount of ebullition in the still, and the operation will progress with so much difficulty that it will become extremely expensive to push it to the end. If, on the other hand, it is desired to distill essential oils in the water bath having only water in the boiler for the transmission of the heat, it will be impossible.

Under some circumstances oil and other liquids may be used in the water bath to produce a greater degree of heat than that of the liquid to be distilled. But it may happen that these substances by becoming more and more concentrated may change in character and in their boiling point, and that an imperfect result will be obtained. Yet there is advantage in most cases in the use of these agents; it is at least certain that they will not exceed a given degree of heat, and that the temperature will be uniform in all parts of the liquid.

Distillation by *steam* should be conducted as follows:—

Commence by filling the steam boiler three-fourths full of water; see that the safety valve, the water, and steam gauge work well; kindle the fire under the boiler so as to set the water boiling to produce the steam. As soon as the steam gauge indicates the proper pressure (one and a half or two atmospheres), the cock which admits the steam to the pipe connecting the still with the boiler is opened one-fourth so as to heat the liquid to be distilled very gradually, then it should be opened one-half, and then entirely when it becomes necessary.

As to the still, it is arranged and managed just as in the distillation by the *naked fire* and *water bath*.

The steam boiler must be frequently cleaned; the water by evaporation forms a deposit, especially when *calcareous* waters are used; in this event it will be necessary to introduce into the boiler either flour, starch, or potatoes; by this means the formation of a *calcareous* deposit is prevented, and the boiler is protected from injury.

Distillation by *steam* is, without doubt, preferable to any other method in the threefold relations: 1, economy in fuel; 2, superior quality of the products; 3, facility of the working. Nevertheless, the heavy expense which the application of steam requires at the start prevents this method of distillation from being employed except in large establishments.

Distillation by the *sand bath* and *retort* are but little used except in chemical operations; the liquorist rarely has occasion to employ them.

Rectification.

We have already said that the liquorist never distills spirits except with the view of associating with them certain aromatic substances. Distillation for the purpose of obtaining trois-six spirit is not essential for liqueurs. Now, the aromatics which are to be combined with brandy or spirit by means of distillation being of different kinds, either on account of their oily or resinous nature, it follows that the process of distillation should vary accordingly. If the aromatic is very subtile, like that in leaves and flowers, or if it is desired that the spirit should retain only a small portion of it, distillation by the water bath is to be preferred; if, on the contrary, these aromatics are refractory or heavy, they can be separated from their original compounds only by distillation over the naked fire; still it is necessary to be observed that a portion of the feints or phlegm should be allowed to pass over towards the end of the operation. These feints, which require a very high degree of heat,

only are capable of volatilizing such aromatics; but, as in this case, the liquid is often acrid without being on that account empyreumatic, it is indispensable that it should be redistilled in a water bath in order that the more subtile and aromatic parts once separated may pass over with the spirit.

Rectification consists in pouring into the water bath of a still the liquid already distilled, and adding to it a certain quantity of water, which under these circumstances causes the volatile oil which is in excess to collect in globules on the surface of the spirit from which it has been separated. It has also for its object the removal from the aromatized spirit of the acrid and empyreumatic flavors which it may have contracted, or rather the feints which may have come over during the course of a distillation pushed to excess. To conduct this operation properly, it is necessary, on the one hand, to watch the fire, and, on the other, to renew the water in the cooler frequently.

Rectification is frequently confounded with *cohobation*. To *cohobate* a liquid is to pour the already distilled liquid on the residuum of the distillation in order to continue the operation which this return of liquid has not interrupted. Now, it is certain that the practice of cohobation is more injurious than useful. The long sojourn of these substances, exposed to heat in the still, causes them to contract an acridity from which the distilled liquid is not exempt.

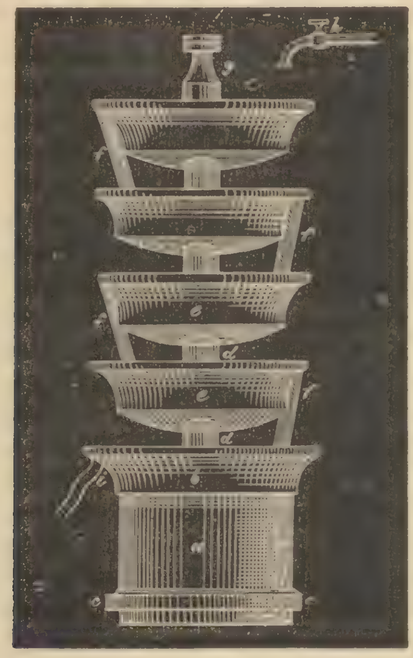
This is not the case in rectification: whenever the distillation is conducted over the naked fire, the rectification of the distilled liqueur is essential to the production of a delicate aroma.

For some years a column of plates has been successfully used in the manufacture of liqueurs and perfumery, for the rectification and concentration of spirits.

This column is applicable in the manufacture of liqueurs when it is necessary to distill the marc of currants, or the remains of brandied fruits, feints, or other products, from which it is profitable to extract alcohol. This piece of apparatus is mounted directly on the boiler or the water bath of a common still.

The following is a description of this column, which has been so well constructed by M. Egrot as to leave nothing to be desired. We indicate also the method of using it (Fig. 11).

Fig. 11.



a, base of the column; at the bottom of this piece is a circular collar *c c*, which fits perfectly to that of the boiler or the water bath.

b, first basin soldered directly on the base *a*. There is within this basin a convex bottom, from the centre of which rises a pipe *d*, for communication with the vessels above. This pipe supports a second basin, but distinct from that below; this also has a convex bottom. On one side there is a level pipe which, passing out at the edge of the basin, connects by means of the conical pipe *f* with that below (*b*), and dips to the bottom of it. The column is completed by a number of basins exactly like the last, except that the level pipes are placed alternately on opposite sides.

g, is a continuation of the tube *d*, which affords a means of escape for the alcoholic vapors after they have circulated in the column; a bridle at its upper extremity serves to make its connection with the goose-neck which conveys the vapors to the cooling coil.

When alcohol, the flavor of which is objectionable, is to be distilled, the column is placed on the water bath of an ordinary still (Fig. 3, Pl. I.); the goose-neck is then attached by means of a connecting pipe having the same height as the column, and serving to complete the connection of the goose-neck with the coil; all the points are then covered with bands of cloth covered with flour paste, and heat is applied to the apparatus.

The water bath being sufficiently full of the liquid which is to be distilled, is heated by the water contained in the boiler and soon begins to boil. The alcoholic vapors evolved rise under the bottom of the first basin *b*, and pass through the pipe *d* into the bottom of the second basin, where they circulate in the space left between the two bottoms, both being convex outwards. This space or cavity, from its form, is called *the lentil*. There is a similar cavity in the bottom of each of the basins above, and the vapors in their upward course must pass through them all where they are regularly and progressively cooled and despoiled of their essential and empyreumatic oils, and at the same time increased in degree by the refrigerating influence of a stream of cold water through the cock *h*. The water which flows through the cock *h* falls into the upper basin, which it fills, and then flows over by the level pipe *f*; this second basin being full, overflows in its turn to fill that below, and so on in succession, until the cooling liquid reaches the lowest basin *b*, from which it flows off by the level pipe *i*. It is easy to understand that the alcoholic vapors, in their passage through the different basins, constantly come in contact with a cooling medium, which is colder and colder as they ascend, and thus they will be thoroughly purified, and that products which were before unfit for use may be employed after their rectification.

This column is of moderate cost, and occupies very

little space. In perfumery it is used for increasing the strength or degree of commercial alcohols and producing them almost in an anhydrous state (95 or 97 degrees).

The Selection and Preservation of Aromatics and other Substances.

The quality of liqueurs and the other products of the liquorist depends in a great measure on the selection of the materials used. It is very important to acquire the knowledge which is necessary to their purchase and preservation. It is hardly within the limits of this work to enter upon a lengthened description of the choice, properties, sources, and means of detecting adulterations in each of the substances, as all of this information is presented in far better form than would be possible here, in many special treatises. We will, however, give a few general hints which may be useful to the reader.

Flowers.—The flowers which are freshest and have the greatest amount of odor are to be preferred; it is not only important that they should have been freshly plucked, but that they should be full blown and dry; those should be rejected which have been plucked in rainy weather, or have been dampened to increase their weight and make them appear fresher; the beginning of fermentation which this moistening produces, in great measure destroys the perfume of the flowers and gives rise to a disagreeably herbaceous odor.

Fruits.—Fruits having the best flavor and color are to be preferred. We should carefully avoid the employment of such as may not be fresh, or may have been heated in transportation, or that have been pulled in wet weather. Excessive ripeness is equally objectionable. Fruits with a sound and smooth skin should be preferred; this is a proof of quality.

Plants.—Plants are bought and sold either fresh or dried. They should be gathered in clear dry weather, after sunrise, after the dew and moisture have evaporated. Those that are healthy and most vigorous in growth are to be preferred. The cultivated aromatic

plants of our climate, when well kept, are more odoriferous, and yield a greater proportion of volatile oil than those that are not cultivated.

When plants are to be dried for preservation, foreign herbs, black, dead, or wilted leaves are picked out, the large stems and stalks are thrown aside, and the plants are spread in thin layers on dryers of boards or wicker work, care being taken to turn them from time to time until they are perfectly dried. It must be observed that the plants should not be placed on the dryer in too large quantities, lest they should ferment, or cause the leaves to turn yellow. The exposure of the plants to the heat of the sun is also to be avoided, especially for those intended for coloring purposes. They should be dried in a warm place, either in an attic or a drying room.

Dried plants should be preserved, wrapped in paper, in packages of moderate size, and protected from moisture in order to prevent moulding.

Seeds, roots, woods, and other drugs.—The liquorist generally purchases these substances already dried; we should select seeds which are full and plump, roots sound and very dry, and woods hard and compact.

All substances are more or less deteriorated by moisture; it is therefore this inconvenience which is mainly to be guarded against. This desirable result is attained by preserving them in a dry place, and in closely covered boxes, as well as insuring them against dust and atmospheric influences.

It is of the highest importance to make a careful selection of aromatics and other substances; it is impossible to obtain satisfactory results if the materials have suffered the least alteration. We should therefore consider the quality first, without regard to cost, which often varies but a trifle for inferior articles. Ten, twenty, or even thirty centimes more per kilogramme is a trifle to the liquorist, and will most generally be sufficient to justify the dealer in making a fair delivery. In conclusion, goods of the first quality must be procured without stinginess, if success is to be attained.

CHAPTER XV.

Water.

Of all substances that exist on the surface of the earth in a liquid state, water is the most important, both on account of its utility and abundance. Indispensable to the existence of all living beings, it is the drink of man and beasts; without its assistance, plants cannot grow, nor seeds germinate. In fine, without this liquid, organized existence would be impossible, and if, by an unhappy chance, it should disappear from the surface of the globe, all things would return to that chaos which characterized the infancy of the world.

Water is a liquid, transparent, colorless, without either odor or taste, very little compressible, consisting (chemically) of one volume of oxygen and two of hydrogen, or 88.90 parts of oxygen by weight, to 11.10 parts of hydrogen. Water exists in the three separate and distinct forms of *liquid*, *gas* or *vapor*, and *solid*.

As a liquid.—Water in this form constitutes those masses, of greater or less extent, which cover almost three-fourths of the earth's surface, under the names *seas*, *rivers*, etc., for running waters; and *lakes*, *ponds*, and *marshes*, for standing waters.

As a gas.—Water always exists in the atmosphere in the form of gas or vapor. At first invisible, it passes through various forms to constitute fogs, clouds, rain, and dew; combined with a great quantity of caloric, it is converted into vapor and increases its volume very considerably.

As a solid.—Water passes from the liquid to the solid state in two ways: first, by the lessening of its temperature; second, by its combination with salts or other substances.

In the former it constitutes *ice*, which remains per-

petually on the tops of high mountains, and is always formed when the temperature falls below *zero;* as *snow* and *hail*, which fall from the clouds under certain circumstances. In the second case, when it is solidified by combining with a salt, it is called water of crystallization; poured on other substances, as, for example, lime or plaster, it combines with them so intimately that it is no longer appreciable either to the sight or the touch.

As water has the property of dissolving a certain quantity of gas, and many salts and oxides, that from *springs*, *rivers*, and *ponds* very frequently contains more than the two elements (oxygen and hydrogen). We may find in it carbonic acid, alumina, calcareous earths, the debris of decomposed vegetables, etc. These substances, although in small quantity, are sufficient to render it unsuitable for drinking, or for use in liqueurs. The presence of calcareous salts, so common in the water of wells, renders it *hard;* they curdle soap and render its solution flocculent, harden vegetables, and hinder rather than promote digestion. When in the objectionable conditions indicated, and water is not of good quality, it must be boiled, then decanted after cooling, and filtered.

The presence of lime and its salts is easily recognized by means of the solution of oxalate of ammonia (1 gramme to 30 grammes of distilled water). A few drops of the solution are poured into the water suspected of containing lime; if a precipitate is formed, new portions are added until the water is no longer troubled. The precipitate should present the following characteristics: when held in suspension by shaking the liquid containing it, it appears to be formed of a multitude of crystals, which, by the reflection of the light, present a pearly lustre. Collected on a filter, washed and dried, if it is subjected to the action of heat it is decomposed, leaving a residuum which consists of carbonate of lime or quicklime, according to the degree of heat employed.

Of all potable waters, the purest supplied from natural sources is rain collected in the open country in large vessels, but only after the atmosphere has been purified,

by showers, of earthy substances which the winds sometimes carry to a considerable height. Rain water that falls on the roofs and is collected by means of gutters is not pure, but nearly so; it is charged with calcareous salts which it dissolves from the tiles or the plaster on the sides of the houses.

Water is the intermediate agent of all the operations of the liquorist; he should be careful to employ only such as is of irreproachable purity and limpidity; it is therefore indispensable that it should be filtered before being employed in the various operations.

Filtration and Preservation of Water.

Water is filtered by various processes.

That most commonly employed, is by means of a filtering fountain of stone: but water, although perfectly clear after passing through the porous stone filter, is not freed from the odors it may possess.

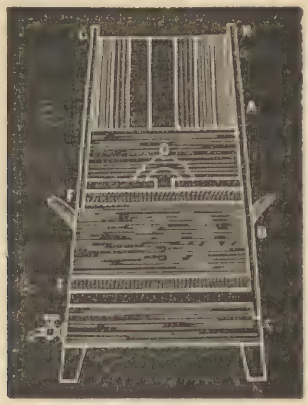
Filtering through paper, with or without a bag, gives precisely the same results.

The antiseptic and decolorizing properties of charcoal have been taken advantage of, to render the most brackish and offensive waters potable, by depriving them of the organic and odorous substances which affect their taste, or disturb their transparency. For the purpose of utilizing these properties, purifying filters, the employment of which is indispensable, are used, and in an infinite variety of forms. We insert a description of one of these filters.

A conical or cylindrical tub lined with sheets of lead soldered together (Fig. 12); within it is divided into three separate compartments, A, B, and C, by two fixed partitions. The first has an opening in the centre covered by a perforated hemisphere of metal D, which is surrounded by a sponge for retaining the grosser particles suspended in the water; the second is perforated with many cylindrical holes. The first compartment receives the impure water; the second has two layers of sand, E F, separated by a layer of charcoal; the third receives the

purified water which is drawn off by the cock. There are against the sides of the vessel two small tubes, A and

Fig. 12



Water filter.

H, intended to afford a way of escape for the air contained in the two compartments B and C, as the water enters them.

This filter may be used for six months without its being necessary to clean or change it. At the end of this time the charcoal must be changed; it may be used for culinary purposes after being dried.

Water purified by charcoal is found to be deprived of its atmospheric air, which is absorbed along with the putrid gases. It is therefore necessary to agitate this water vigorously for some minutes, in order to restore the air which it has lost during the filtration.

Water filtered through charcoal may be preserved indefinitely in close reservoirs of lead or zinc, or in tight hogsheads; if in the latter case, two or three per cent. of alcohol should be added.

Distilled Water.

It is impossible to find perfectly pure water in a state of nature. It is necessary then to have recourse to distillation to purify it. For this purpose the turk's head still is used in the following manner:—

A certain quantity of water is poured into the still; the vessel is placed on the furnace and the cap adjusted, and the coil attached to the arm of the cap. After luting all the joints of the apparatus with strips of cloth or paper saturated with flour paste, the cooler or flake-stand is filled with cold water; the fire is then kindled and the distillation kept up until about three-fourths of the quantity of water employed is drawn off. The water converted into vapor by the ebullition passes through the arm of the cap into the coil, where it condenses by contact with the cold water of the cooler and is collected in the receiver. This vessel should not be closed tightly, because the great quantity of air and highly rarified vapors which are disengaged from the still may burst it, or interfere with the success of the operation. The first products which pass over should be rejected, because they may contain ammonia, carbonic acid, or the results of some decomposition: they may also bring with them other foreign substançes. It should be remarked that a worm (coil) which has not been used for a long time yields water charged with the oxide of lead, the first time it is used for distilling this liquid.

Distilled water has neither odor nor taste, and is perfectly clear and limpid. Protected from contact with the air, it may be preserved an indefinite time without contracting any disagreeable odor, or being injured.

Its insipid taste, and the oppression which it causes in the stomach, render it unfit for drinking. Distillation, while it separates the foreign substances from the water, deprives it of its air, and renders it indigestible; nevertheless, its original virtues may be restored by agitating it violently in contact with the air.

Distilled water may be sought for from the liquorist by persons engaged in chemical pursuits, or he may himself have use for it under some circumstances. Its purity is determined by its not being troubled by the addition of solutions of nitrate of silver, acetate of lead, and the soluble salts of lime and baryta.

CHAPTER XVI.

AROMATIC WATERS.

Aromatic Distilled Waters.

UNDER this name are comprised all the aromatic products which are obtained by employing simple water for dissolving them.

The aromatic waters owe their properties to the presence of a certain quantity of volatile oil which they dissolve from the substances from which they are obtained. Nevertheless, there are many of them which do not owe their odor and other properties alone to these volatile oils; in fact, many plants or parts of plants are known which yield, on distillation, products having an odor differing from that of the volatile oil of the same substance. For example: the odor of the distilled water of orange flowers does not resemble that of neroli, and it is the same with water of valerian and some others. If we observe, moreover, that many highly aromatic plants, as reseda, tuberose, jasmine, etc., do not contain any volatile oil, it must be inferred that these oils are not always the cause of vegetable odors. It is for these considerations that the ancients claimed for each substance a peculiar odorous principle to which they gave the name of *aroma*, and which Boerhaave called *spiritus rector*.

Aromatic distilled waters serve for compounding liqueurs to which they impart a perfume and delicacy which are not obtained by the use of aromatized spirits.

The distillation of waters requires much care and attention; the management of the fire also has great influence on the quality of the products obtained, which frequently have a bad flavor and empyreumatic odor. It is important, therefore, not to allow the operation to drag, and to avoid operating on masses that are too large, and not to fail in renewing the water in the cooler. The

preservation of distilled waters becomes impossible, if during the distillation any portion of the *decoction* passes over into the receiver. It is also necessary to avoid packing the materials too much in the bottom of the still, and not to allow the latter to lack water.

The rules to be followed are:—

1. The plants or parts of plants intended for distillation should be gathered during that period of the year when their odor is fully developed. It is also necessary to cause them to present as great a surface as possible; for this purpose, woods are rasped, roots and barks are crushed; but aromatic plants should be employed simply cut, so that they may lose no portion of their odorous principle. In conclusion, care should be taken to allow woods, roots, and dried barks, whose texture is very close, to macerate some time, in order that the water may be enabled to penetrate them.

2. If the substance is possessed of but little odor, it becomes necessary to cohobate it many times, by treating the liquid obtained from a preceding distillation over fresh supplies of the materials.

3. If, on the other hand, the substance is odorous, a sufficient quantity should be placed in the still to saturate the water completely.

4. The still should contain enough water to insure its contents being covered until the end of the distillation. The more succulent substances require less water.

5. It is necessary to prevent any portion of the contents of the still from passing over into the receiver in its natural state.

6. For fear that substances may be softened and form a paste on the bottom of the still, they should be supported on a grate, or, better still, in a perforated water bath.

7. The water must be rapidly heated to the boiling point and so maintained to the end.

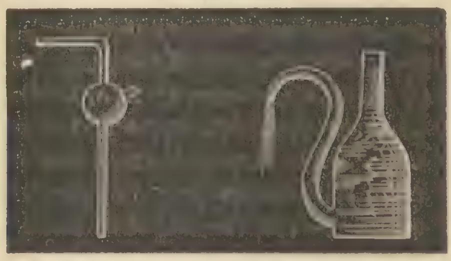
8. The water in the flake-stand should be renewed as often as possible.

9. Fresh materials are preferable to those which have been dried; they yield a sweeter and more odorous pro-

duct; there are sometimes exceptions which will be pointed out as they occur.

10. Aromatic waters should be collected in a glass receiver, which is shaped like a bottle, the neck of which becomes smaller as it rises; at the bottom is a spout, which rises along the body of the principal vessel, but which does not rise quite to the full height of the neck. By this arrangement, the volatile oil, commonly lighter than water, rises into the neck, and the water flows off at the extremity of the spout as the distillation progresses. This is called the *Florentine receiver*, so called from the city in which it was invented (Fig. 13). The volatile oil which floats on the surface is removed by the pipette (Fig. 13).

Fig. 13.



Pipette. Florentine receiver.

11. It is indispensable to filter aromatic waters after their distillation to separate the small quantity of oil which may be held suspended, and which renders them acrid and not very agreeable.

Contrary to the opinion of the ancients, it is important not to omit the use of common salt, which is necessary for the distillation of aromatic waters and essential oils obtained from flowers. Its effects are: to *sharpen* the water and render it more capable of penetrating and dividing the vegetable substances; to prevent fermentation from being set up when operating on dried materials which have to undergo a preliminary maceration; and, finally, to increase the temperature of the water, and thereby facilitate the disengagement of a greater proportion of volatile oil.

An experiment was made some years ago by a distinguished chemist, M. Couerbe, as follows:—

"With the assistance of sulphuric acid I have macerated the flowers of roses, linden, elder, and orange. Before the addition of the acid, the different macerates had but a feeble odor, but it was decidedly increased and strongly developed by the admixture of sulphuric acid. This phenomenon recalled a passage which I had read in a very ancient book (*Magni Alberti liber secretorum de Vertutibus herbarum, lapidum et animalium*, 1478), which says, that to procure odorous water of roses promptly, it is sufficient to place some roses in a common bottle full of water and add to the mixture a small quantity of oil of vitriol, and after a quarter of an hour, to filter the liquid. I have tried this experiment and found it to succeed admirably. I had, in fact, the odor, and the color of roses as well. I then applied this method to the distillation of roses, the flowers of linden, violets, and elder, by placing them in a retort with ordinary water slightly acidulated with oil of vitriol; the product I obtained was a very pleasant liquid, in no wise acid, without any odor of sulphur, and not yielding a precipitate with any of the caustic solutions. I do not know whether in time it will experience any change in its principles. It is possible, that the mucosity which forms even in inodorous distilled waters may not originate in this."

It should be remarked, that when a dried plant is distilled with water, the volatile oil having experienced some change by contact with the oxygen of the air, has become less soluble: consequently more of it should be obtained in a free state. The same effect is produced when a fresh plant is used; if the distillation is commenced with cold water, the oxygen contained in the water acts on the oil, effecting such an alteration as to render it insoluble in the water: consequently it will separate from the water in this case likewise; but if, on the contrary, boiling water is used at the commencement of the distillation, or what amounts to the same thing, if the fresh plants are suspended in the vapor of water, the volatile oil experiences no alteration, and is more completely dissolved.

For the same reason, those volatile oils which are most susceptible of alteration yield the least highly charged distilled waters, and reciprocally. This is in effect what happens with the waters of cinnamon, cloves, and mint; their turbid appearance indicates that the volatile oil. is very imperfectly dissolved, whilst the limpidity and the intense odor of rose water evidently prove that it holds in solution a considerable proportion of the volatile oil. This volatile oil of roses is one of the least alterable.

From this we may infer, in the preparation of distilled waters and volatile oils, that it is by no means a matter of indifference whether the plants are dried or fresh, or the temperature of the water hot or cold, or the quantity greater or less. These circumstances, or any one of them, may greatly influence the results, both as to quantity and quality.

Aromatic waters are distilled in either the turk's head or column still. With the first, the perforated water bath must be used for those substances which will be pointed out; the application of the method of Soubeiran with the same still offers some advantages over the use of the perforated water bath. The second will be preferable, particularly if conjoined with the separator of Egrot (described on page 49).

Distillation by steam is to be preferred for plants of pleasant and delicate odor; the products so obtained may be used at once, because distilled waters prepared by this method are free from that empyreumatic flavor, called *taste of the still*, which the most carefully prepared waters distilled over the naked fire always have, and retain for quite a length of time.

The following plants should, as a matter of preference, be distilled by steam:—

Absinthe,	Hyssop,	Sage,
Anise,	Lavender,	Wild Thyme,
Caraway,	Melilot,	(*Serpolet*),
Citronella,	Balms (*Melisse*),	Garden Thyme,
Fennel (*seeds*),	Mint,	(*Thym*).
Juniper,	Orange (*Flowers*),	
	Rose (*Flowers*).	

The following substances are, on the other hand, distilled more successfully when mingled with the water, viz :—

Bitter Almonds, Cinnamon, Cloves, Mace.

Preservation of Aromatic Distilled Waters.

Aromatic distilled waters very soon spoil; they ought to be renewed as often as possible. They should be kept in opaque vessels in a cool place, and protected as much as possible from the light, which decomposes them.

The vessels which contain aromatic distilled waters should be stopped as closely as possible (it is a great mistake to suppose that air is necessary for them); for this purpose paper or parchment is best, for experience has proven that if the cork is covered with cloth, they in a short time acquire a mouldy taste. Orange flower water may, however, be kept a year, or even more, in a tightly corked bottle, without its acquiring any disagreeable property; but as soon as it is opened the cork must be thrown aside, and paper only used instead.

Generally, aromatic waters, immediately after their distillation, have not a very pleasant odor; they all have an empyreumatic flavor which disappears in time. This taste may be removed at once by immersing the vessel containing them in an ice bath; nevertheless, although cold does improve the quality of aromatic waters, they must be protected from freezing during winter. The water, after thawing, remains turbid for some days, but becomes clear by depositing a considerable quantity of sediment, which retains a portion of the odor of the plant, which assists in the preservation of the water. If under these circumstances, the water is separated from the precipitate, it will be found to have only a feeble vegetable odor, agreeable, it is true, but of little durability.

Almost all distilled aromatic waters, after a few days, contain mucilaginous flocks, which remain in a state of suspension, or are precipitated : it is therefore necessary to filter them frequently. Then it happens that the

waters are spoiled within a year because they are distilled with too great heat, and in too large quantity, which causes the mucilaginous parts of the plant to pass over into the receiver. This accident does not happen when the distillation is carefully conducted. When aromatic distilled waters become turbid from this cause, they may be clarified by throwing into them eight or ten drops of vinegar to each litre of water, and then filtering.

The limpidity of aromatic distilled waters which have become turbid in consequence of the decomposition occasioned by the causes indicated above, may be very conveniently restored by adding to each litre of damaged water two grammes of borax, and as much alum. The reaction of these two salts results in a flocculent precipitate, which clarifies, and in some measure decolorizes the waters; but this process is applicable only in perfumery, because this addition, however small, still produces an effect which may modify the character of the distilled waters. There are certain waters, and particularly the water of orange flowers, which by decomposition become very acid; in this event the means just indicated will be insufficient. It will be necessary to use magnesia, about two grammes to the litre, or according to the degree of the acidity. This species of alteration may be prevented by adding a little of this base in advance, but then it will be necessary to use four grammes, magnesia being almost insoluble in non-acidulated water.

The method we are now about to explain will prevent all the inconveniences attached to the employment and preservation of aromatic distilled waters. After having distilled any aromatic water whatever, with all the care which this operation requires, it is immediately returned to the still, which has in the meantime been thoroughly cleaned, and again distilled very gently. When the water which is distilled off becomes too weak, the operation is suspended, and the first product only is preserved in well-corked flasks. The waters of orange

flowers, hyssop, melisse, and mint, so prepared, remain in good condition for four or five years.

Method of Depriving Aromatic Waters of their Odor.

Mr. Davis, a druggist of Chester, England, having chanced to make a mixture of equal parts of castor oil and peppermint water, observed that the taste and odor of the latter diminished gradually until after one or two days it had disappeared entirely.

The same effect is produced with other distilled waters or volatile oils mixed with water in the proportion of one drop to 60 grammes of water. Olive oil substituted for castor oil produces the same effects.

This discovery, promulgated as original, is not, however, new, since it is well known that the fixed oils are better excipients of the volatile oils than water. Thus, when a fixed oil is mixed with water charged with a volatile oil, the latter is easily absorbed and removed by the fixed oil. If this oil is not sensibly impregnated with the odor and taste, it is because the volatile oil is more masked than when dissolved in the water.

Receipts for Aromatic Distilled Waters.

Small operations for the distillation of aromatic waters are infinitely preferable to those on a large scale; this will explain the reason why our receipts are for small quantities. It should be observed that three or four litres more than the quantities indicated ought always to be drawn off, in order to secure all the perfume contained in the materials; this last product should be reserved for use in a new distillation.

The quantities we give may not always produce the same results. The quality of aromatic distilled waters depends on the season when the flowers, plants, etc., have been gathered. Their perfume is more highly developed during a hot season; in seasons that are cold and rainy, they contain less perfume. It is for the liquorist to decide whether he will retain or increase the

quantities given in the receipts, in order to have his aromatic waters constantly of the same quality. The products may also be *fractioned* (separated), and in such manner as always to have the waters invariably the same. The receipts here given are based on a favorable season.

Water of Orange Flowers (*Eau de Fleurs d'Oranger*).

Orange flowers fresh gathered and picked from the calices	5 kilogrammes.
Common water	40 litres.
Common salt	500 grammes.

After putting the water and salt into the still, the fire is kindled in the furnace, and the liquid heated nearly to the boiling point. At this moment, turn the flowers at once into the perforated water bath, or into the Soubeiran still; adjust the cap upon the still, connect the coil, lute all the joints, and place the florentine receiver under the end of the coil to catch the product; then go on with the distillation until twenty litres of *simple water of orange flowers* are drawn off.

If it is desired to obtain a *double* or *triple* water, only the half or one-third the quantity indicated is drawn off; or the distilled water is poured back on fresh flowers in quantity proportioned to the quality which it is desired to obtain.

This distillation should be conducted rapidly, so as to leave the flowers in contact with the heat the least time possible; it affects the character of the product.

We have already said that orange-flower water, as other aromatic waters, distilled in the manner we have described, that is to say, putting the flowers into the still only when the water is beginning to boil, is much clearer than when the flowers are put into the still with cold water.

It is to be observed that orange-flower water is more agreeable and sweeter when the petals of the flowers only are used; the calix and organs of fructification give a decidedly bitter flavor.

Orange-flower water, among other principles, frequently contains, as it runs from the still, free acetic acid, which may, if thought proper, be neutralized by putting in the still 15 grammes of magnesia to each kilogramme of flowers.

Orange-flower water becomes solid at a temperature of three degrees below zero, yet it remains limpid after congealing; but, if examined closely, an infinite number of very delicate, pearly particles will be observed in the liquid, which finally settle on the walls of the vessel in the form of a reddish-brown incrustation insoluble in water. This sediment appears to be the volatile oil resinified.

Orange-flower water, which has been frozen, has a more agreeable odor than before; but it is very evanescent; within two months at most it becomes acrid and completely spoiled.

The orange-flower waters of commerce, which come from Provence in barrels and cans, are most frequently the result of the distillation not only of the flowers, but of the leaves and the fruit of the orange. Those waters, which grocers and other dealers sell at a very low price, have an odor analogous to that of the orange leaf when bruised or pressed between the fingers; their flavor is decidedly bitter, and by no means agreeable. The difference between these waters and that prepared from the flowers alone is readily appreciated by the taste; nevertheless, there are some persons who do not hesitate to add acetate of lead to these imitations of orange-flower water for the purpose of improving them. There is no necessity for our remarking on the impropriety of such a practice, and the great danger there is in using these waters. This falsification is easily detected by pouring into the suspected water a few drops of a solution of tartaric acid (15 grammes of acid to 30 grammes of water); an abundant precipitate is formed.

As was said above, orange-flower water frequently contains free acetic acid, of which the proportion is sometimes so large as to be sensible to the taste, and will affect the color of litmus paper. When these waters

chance to be in contact with copper, as is the case with those brought from the south in cans, they contract a disagreeable metallic taste, and may prove injurious to the health. The copper is detected in such waters by the addition of a few drops of liquid ammonia, which in the presence of cupreous salts produces a beautiful blue color.

Orange-flower water is greatly used in the manufacture of liqueurs; it is frequently employed in domestic economy, and enters into the composition of many pharmaceutical preparations.

Methods of ascertaining the Quality of Orange-Flower Water.—Nitric and sulphuric acids have the property of communicating to orange-flower water a more or less intensely red color, as this water is more or less highly charged with the volatile oil of orange flowers. The following is the method of proceeding with sulphuric acid: A certain quantity of water of the first quality is poured into a wineglass, and into another glass the same quantity of water under examination; then to each is added an equal quantity of sulphuric acid. The tints are then compared, and it is determined, by the intensity of the color in the water tested, whether it approaches the quality of that which is used as a standard in the experiment.

Concentrated sulphuric acid acts more promptly. Orange-flower water, properly prepared, when brought in contact with this acid, in a few minutes develops a beautiful rose color. By adding the acid in greater quantity, the color appears more promptly, and is of deeper tint; and by using a quantity of acid equal to that of the water, a beautiful red color is produced which remains unchanged for two or three days; the color passes to a crimson, if the mixture is slightly heated, or the quantity of acid doubled.

It is important to observe that the color is produced more promptly when the water is poured on the acid at once, than when added gradually in small portions.

The color produced by nitric acid disappears when

the acid is neutralized by an alkali, and is reproduced anew on a fresh addition of acid.

Rose Water.

Petals of fresh roses . . .	20 kilogrammes.
Common water	40 litres.
Common salt	1 kilogramme.

Distill by steam in a perforated water-bath, until 20 litres of the product are drawn off; and follow the directions given for orange-flower water.

An excellent rose water may be prepared from the flowers preserved in salt. The flowers, in the proportion of two parts to one of salt, are rubbed together, and may be preserved in this condition more than six months. The roses become brownish, but, nevertheless, yield a water which, for sweetness, leaves nothing to be desired.

Fermentation has been used for some years by many chemists for obtaining rose water. M. Cenodella, among others, has published the process, as follows: The petals and stamens of the roses are introduced into the still with the necessary quantity of water, the cap is adjusted to its place, and the whole suffered to macerate for some days, or until a vinous odor begins to manifest itself, care being taken in the meantime to stir the mixture occasionally; then to distill off a very odorous rose water. M. Cenodella adds that a similar quantity of roses, distilled in the usual way, yields a less aromatic water.

This method of preparing rose water is not new; a description of it is found in most of the ancient books on chemistry, especially in the *Antidotarium Bononiense* (Venice, 1766); but still we cannot say that it produces good results. Besides, the time which this process requires, at the season when roses are distilled, appears to be a sufficiently serious obstacle, and a reason for preventing the experiment being attempted.

Rose water, distilled from the flowers without separating them from their calices, has a disagreeable odor and an herbaceous taste. Prepared under favorable condi-

tions, it is successfully employed in the manufacture of various liqueurs; in medicine it is used as a vehicle in potions and collyria.

The presence of the salts of copper in rose water is detected by the process described in the article on *Orange-Flower Water*.

Water of Violets (*Eau d'Oeillets*).

Violets (flowers) separated from the calices	10 kilogrammes.
Common water	40 litres.
Common salt	250 grammes.

Distill to procure 20 litres.

Conduct the operation as for the preceding waters.

Water of Absinthe (*Eau d'Absinthe*).

Leaves, tops, and smaller stalks of absinthe	20 kilogrammes.
Water	40 litres.
Salt	250 grammes.

Cut or chop the stalks of absinthe into pieces of 20 or 25 centimeters long. After macerating for twenty-four hours, distill rapidly to draw off one-half of the water employed.

When there is a large quantity of absinthe to be distilled, the maceration may be omitted.

The first portions of water distilled are white and milky, and bring with them a certain quantity of volatile oil, which separates and floats on the distilled water in the florentine receiver.

When the operation is finished, this oil is removed by the pipette.

In the same way are obtained the aromatic waters of citronella, marjoram, rue, and origanum.

Water of Hyssop (*Eau d'Hysope*).

Fresh tops and flowers of hyssop	10 kilogrammes.
Water	40 litres.
Salt	250 grammes.

Introduce the tops and water into the still, then after maceration, distill off 20 litres.

By the same method are obtained the waters of lavender and melilot.

Peppermint Water.

Fresh peppermint, in flower . .	10 kilogrammes.
Water	40 litres.
Salt	250 grammes.

After maceration draw off twenty litres.

The waters of balm (*melisse*), curled mint, rosemary, sage, lemon thyme (*serpolet*), garden thyme, are prepared in the same manner.

Water of Tea (Eau de Thé).

Imperial tea	1 kilogramme.
Hyson tea	500 grammes.
Pekoe tea	500 "
Water	40 litres.

Place the three kinds of tea together in the still, pour in the water, which should be boiling, close the still hermetically, and allow it to infuse for three or four hours, then distill rapidly until thirty litres are drawn off.

Anise Water.

Anise seeds dried and bruised .	5 kilogrammes.
Water	40 litres.
Salt	250 grammes.

After a maceration, distill off twenty litres. The water in the cooler should be tepid, in order that the oil contained in the water may not solidify and cause an obstruction in the convolutions of the coil. If this concretion should take place, the distillation must be discontinued.

Water distilled from anise seeds is not affected by freezing, for it resumes all its characteristics when exposed to a temperature higher than that which caused the separation of the volatile oil; but if the water, which floats above the crystals formed by the cold, is poured off, it will be perceived that it has lost its perfume.

The following waters are prepared in the same way:

Dill (seeds)—star anise (*Badiane*)—caraway (seeds)—fennel (seeds)—juniper (berries).

The same precautions in regard to the cooler, as indicated for anise water, are to be observed for these waters.

Coriander Water.

Coriander seeds, dried and bruised .	10 kilogrammes.
Water	40 litres.
Salt	250 grammes.

Macerate for twenty-four hours, and draw off twenty litres.

The following waters are prepared in the same way: Angelica seeds — skirret — (*chervi*) [SIUM SISARUM] (seeds)—candy carrot [DAUCUS CRETENSIS] (seeds).

Water of Mocha Coffee (Eau de Café Moka).

Mocha coffee	3 kilogrammes.
Water	40 litres.

Toast the coffee slightly, until it has acquired a yellowish-brown tint; then, while still hot, reduce it to a coarse powder, and allow it to infuse for twenty-four hours. Distil off one-half the liquid employed.

Prepare the following waters in the same way: Martinique coffee and Carraccas cocoa—Cohobate twice for cocoa, and distill gently.

Cinnamon Water (Eau de Cannelle).

Ceylon cinnamon in powder .	2 kilog. and 500 gram.
Water	40 litres.
Salt	1 kilogramme.

Cohobate once. Macerate twenty-four hours, distill over the naked fire, without the perforated water-bath, and boil gently until twenty litres are distilled.

The following are prepared in the same manner: Malabar cinnamon, Cascarilla, cloves, mace, nutmegs, sassafras, and rosewood.

It must be observed that cinnamon water is always somewhat turbid. This effect is due to the prolonged suspension of the volatile oil, which, being heavier than

water, falls to the bottom of the vessel. When this water is to be used, it is necessary to shake the vessel which contains it.

After the distillation of the above-named waters, care should be had that the cooler be tepid, in order that the volatile oils, which may have condensed and become obstructed in the coil, may descend. If this precaution is neglected, a portion of the principal products will be lost.

Angelica Water (Eau d'Angélique).

Dried and ground roots of angelica,	2 kilog. and 500 gram.
Water	4 litres.
Salt	500 grammes.

Macerate twenty-four hours, and distill off twenty litres.

Prepare the following by the same process: Elecampane (*aunée*), calamus, cardamom.

Water of Bitter Almonds (Eau d'Amandes Amères).

Bitter almonds	5 kilogrammes.
Boiling water	40 litres.
Salt	500 grammes.

After having removed the fixed oil of almonds by expression, reduce the cake to powder, mix it with the boiling water, and distill off twenty litres.

This water must be employed with great caution, on account of a certain quantity of prussic acid which it contains.

The following are prepared in the same way: Seeds of apricots, cherries, and peaches.

Lemon Water (Eau de Citron).

The rinds of 80 fresh lemons.	
Water	40 litres.
Salt	250 grammes.

Distill off half the water used.

The following are prepared by the same process: Bergamot, cedrat, sweet and bitter oranges.

Raspberry Water (*Eau de Framboises*).

Fresh raspberries (capped) . .	12 kilogrammes.
Water	40 litres.

Without previous maceration, distill with such precautions as to prevent the fruit from attaching itself to the still. Draw twenty litres.

Pursue the same method for the following: Apricots, prunes, quinces, and other fruits.

Maraschino Water (*Eau de Marasquin*).

Black cherries (very ripe) [*prunus avium*] .	20 kilog.
Raspberries (very ripe and capped) . .	4 "
Black cherry leaves . .	1 kilog. and 500 grammes.
Peach kernels	250 "
Florentine orris root in powder . . .	1 kilogr.
Water	40 litres.

Macerate the whole together for twenty-four hours (the fruits having been crushed), then distill off carefully twenty litres.

This receipt is excellent, and the maraschino water, thus prepared, may well rival that which is sold as coming from Dalmatia, but which is really produced in the south of France.

Water of Green Walnuts (*Eau de Noix Vertes*).

Green walnuts	11 kilogrammes.
Water	40 litres.

Take the green nuts, when the kernels have scarcely formed, crush them properly by stamping with a pestle, then distill without a previous maceration, so as to obtain twenty litres, observing the same precautions as for raspberry water.

Aromatic Waters without Distillation.

The non-distilled aromatic waters are imitations of those produced by distillation; they are always put on the market without their origin being made known, and with the intention of creating the impression that they have passed through the still. As it may happen that

the liquorist may be under the necessity of purchasing aromatic waters in consequence of his own supply being exhausted, in order to protect him from this fraud, we shall indicate the processes employed by the counterfeiters and the method of detecting the trick.

These waters are prepared in two ways :—

1. Pour the volatile oil on pulverized sugar, then triturate the mass, adding the water to be aromatized in small quantities at a time, shake the mixture well, and, after a rest of thirty or forty minutes, filter.

2. Pour the volatile oil on carbonate of magnesia, and conduct the operation as above. This method is greatly to be preferred, as the carbonate of magnesia has the property of greatly facilitating the suspension of volatile oils in water.

Aromatic waters, thus manufactured, have a less agreeable perfume than those which are distilled. On account of the difficulty of procuring good volatile oil, they are also defective in not having so fresh a flavor. They may, however, be preserved quite a long time, except those prepared with the aid of sugar, which are very susceptible of fermentation.

The factitious aromatic waters are easily recognized. They develop less perfume when poured into pure water; they are not mucilaginous nor greasy to the touch, and always exhale a somewhat herbaceous odor. Orange-flower water, prepared from the essence of neroli, is nothing like so pleasant as that which is distilled from the flowers.

Apart from the characteristics above mentioned, factitious aromatic waters are infallibly recognized by the means which we are about to indicate.

When examining an aromatic water suspected of having been manufactured by the aid of sugar, the liquid should be evaporated to dryness, and if, instead of obtaining mucilage and extractive matter, we find a saccharine substance which, when thrown on burning coals, puffs up and diffuses the odor of caramel, the suspicion is well founded.

If, on the other hand, the aromatic water is prepared

with carbonate of magnesia, we prepare a test, by making nearly saturated solutions of carbonate of ammonia and phosphate of soda, and filtering them. Having prepared the two reagents as indicated, an ordinary wine-glass is half-filled with the water under examination; into this is poured a small quantity of the solution of ammonia; then if, on adding an excess of the solution of phosphate of soda, the water becomes turbid, and a white precipitate falls to the bottom of the glass (ammonio-phosphate of magnesia), the problem is solved.

The presence of carbonate of magnesia in any aromatic water may be detected by boiling it, and then adding a small quantity of a saturated solution of hydrochlorate of alumina, a precipitate is thrown down, which consists of carbonate of alumina.

CHAPTER XVII.

VOLATILE OILS OR ESSENCES.

THE volatile oils, commonly called *essences*, are proximate principles of vegetables; in their characteristics, they differ entirely from the *fixed* or *fat oils*, in respect both to their physical and chemical properties.

The greater number of volatile oils are generally liquid at the ordinary temperature; some are solid, or partially crystallized; none of them are greasy or unctuous to the touch like the fixed oils, nor have they the appearance of being what is commonly called oily. All of them have a very persistent and penetrating odor, which generally recalls the substances from which they have been obtained, but they are never as fragrant. Generally poisonous, their taste is acrid, irritating, and caustic.

Light changes the color of volatile oils in a remarkable manner; it changes to yellow those that are colorless, darkens or decolorizes those that are colored; the volatile oil of chamomile, for example, which is blue, becomes

yellow. Exposed to the air they change color, lose their odor, thicken, and finally become solid. They take fire suddenly on the approach of a flame, and burn with a very brilliant and dense flame. Highly soluble in alcohol, but little so in water, they boil only at 150 degrees Centigrade, and are distilled without alteration. When heated along with water, they volatilize at a heat not exceeding 100 degrees, and frequently much below that. It is remarked that their volatility is usually in inverse proportion to their density, the most dense being the least volatile.

Cold produces notable effects on them; it congeals them, but at different degrees; many become solid at some degrees above zero, others remain liquid many degrees below.

By age, they undergo changes in color and consistency which are very unfavorable to them; they become turbid, deposit a precipitate, and become so acrid that they redden the ends of the corks in the vessels which contain them. When these accidents occur, it is important to rectify the oils at once.

They have the property of uniting with the fixed oils, and dissolving resins, wax, and caoutchouc; they are generally lighter than water, but there are some which are heavier than that liquid; the lighter are also more volatile.

They are found in all the organs of plants, but they abound especially in the leaves and flowers. According to the opinion of a goodly number of distinguished chemists, they do not constitute the perfume or odor exhaled by these organs; they serve simply as the vehicle for the transmission of the odorous substance, or *aroma*, the nature of which is yet unknown. Boerhaave has defined this odorous principle as follows:—

"This essence," says he, "acts upon our organs of taste and smell; it is active; it is the offspring of fire, and it produces various incredible effects. Innate, confined, and, as it were, bound up in the oils, it communicates a singular and powerful odor which is found nowhere else; but when it has been altogether driven off,

it leaves them almost without strength, so that they can hardly be distinguished one from the other. Now, as a gentle heat is sufficient to drive off this essence of spirit from many oils and dissipate it in the air, the oils which have thus lost it are without strength, and are no longer capable of producing the effects they produced before."

M. Roubiquet has published a remarkable article on the subject of aroma, which we reproduce from the *Annales de Chemie et de Physique*, 2d ser., vol. xv. p. 27.

"The ancient chemists thought that the odor of aromatic substances was due to a peculiar principle which Boerhaave called *spiritus rector*. Macquer contended that this peculiar principle or essence was not the same for all odorous substances, and he distinguished them as acid, alkaline, and oleaginous. When the French chemists were engaged in regulating chemical language, and establishing the modern nomenclature, they gave the name *aroma* to this unknown principle, which they regarded as the essential cause of odor; in the systematic collection of substances, it was arranged among the proximate products of vegetables. Fourcroy, more recently, ascertained that the existence of this substance, which had been admitted on the faith of the ancients, could not be demonstrated in a positive manner; he contended that odors were the result of the solution in the air of a portion of the odorous body itself, and that the intensity of the odor depended on the greater or less volatility of this body. Unfortunately, this theory, so seducing in its simplicity, is not in accordance with well-known facts. In September, 1820, I published some opinions on the subject of aroma, and, without pretending to return to the ideas of the ancients, I think I have demonstrated that in many various circumstances the odor which emanates from a substance is not due merely to a volatilization of a portion of this substance in space, but rather to an actual combination of a substance, often inodorous in itself, with a very volatile product which serves it for a vehicle. It is thus that tobacco, musk, ambergris, and so many other substances, manifest their odor only by the assistance of ammonia. Musk,

well dried in a water-bath, is no longer odorous while the water, which is discharged from it, is ammoniacal. When it is impregnated with ammonia anew, by allowing it to be exposed for some time in the fumes of a *laterine* (as is sometimes done by the perfumers), where this ammonia results from a natural decomposition, the odor returns with all its original intensity. Ammonia is not the only vehicle for odors. I cited, in the remarks above alluded to, the example of the essential oils of certain cruciferæ, particularly that of *black mustard* (*sinapis nigra*). In this case it is certainly not the volatile alkali which causes the diffusion of the odor, since it is known that acids give more strength and piquancy to mustard. It is by no means the oil which of itself communicates this enduring and penetrating odor, for, on allowing it to stand for some days on a well-cleaned metallic surface, it tarnishes it deeply, and frequently the oil almost entirely loses its odor. I presume that these phenomena are due to the presence of sulphur; but it is combined in a manner which is still unknown to us. If, as Fourcroy thought, plants owe their odor to the diffusion of the volatile oil which they contain, how is it, that certain highly odorous plants, such as the heliotrope, tuberose, jasmin, &c., do not yield an essential oil? and how can it be explained that certain essences have, so to say, no analogy with the odor of the plants, or parts of plants, from which they are obtained? It is certain, whatever may be said to the contrary, that neroli does not represent the entire odor of the orange flower, which, on the contrary, is found in the water distilled from this flower.

"All that has just been said demonstrates, it appears to me, that if it is right, on one hand, to include aroma among imaginary substances, we cannot, on the other, be satisfied with a theory which leaves so many gaps. It is necessary, then, to wait until experience shall enlighten us.

"It appears, in my opinion, from all the facts stated, that the odor, which diffuses itself in the air, should not, as a general rule, be attributed to a simple volatilization,

or emanation produced by the odorous substance itself, but rather, in many cases, to a gas or vapor resulting from its combination with a proper vehicle capable of diffusing itself in space according to certain laws. In regard to distilled odorous waters, this would be for many of them a pure solution of this combination; and I can readily suppose, on recurring to the opinion of M. Macquer, that the volatile oils frequently owe their odor to the combination of a variable vehicle with an inodorous oil. This would be solving a problem which has for a long time occupied certain distillers, who regret their inability to deceive at their ease, and who would discover an inodorous volatile oil with which to dilute the rarer and more expensive essences. I will finish this note with one last remark: it is, that the analysis of essence of turpentine, published by M. Houton-Labillardière (*Journal de Pharmacie*, vol. iv.), and that of the essence of lemon, which we owe to M. De Saussure (*Annales de Chemie et de Physique*, 2d ser., vol. xiii.), exhibit an identity of result which indicates a similar composition, and which proves that the different odors which distinguish them arise from causes which exercise very little influence on their entire nature."

As is seen, the state of our knowledge is very imperfect in what concerns the true nature of the perfume of flowers and aromatic substances, and this subject, so full of attraction, has been little studied up to the present time. Nevertheless, one of our eminent chemists, M. Millon, Director of the Central Military Dispensary at Algiers, prepared, in 1857, a very interesting work, which Marshal Vaillant, the Minister of War, presented to the Academy of Sciences. In this memoir, M. Millon makes known a new method of extracting the odorous principle of flowers and plants, from which it appears that the author substitutes a double operation for distillation, expressing or maceration in oil: 1st, solution; 2d, evaporation. He dissolves the odorous principle in sulphuret of carbon, or in ether, on the one hand, and, on the other, he evaporates the solution over a slow fire. By this means, a butter-like substance is obtained, quite

similar to the essence of roses from the East, and this substance reproduces in all its purity, its intensity, and fragrance, the original odor of the flower or plant.

This last product presents the peculiar chemical characteristic of being absolutely inalterable in the air. The *perfumes*, prepared by M. Millon, were preserved entire years in open tubes, without losing any of their peculiar properties. This inalterability of the perfume of flowers and plants, when exposed to the air, constitutes a most interesting discovery. Let us hope that these perfumes, which render so much service to the perfumer, may ere long be successfully employed by the liquorist.

The volatile oils are contained in small glands, which are disseminated throughout the cellular tissue of vegetables. To extract these oils from the organs which contain them, the most common means is distillation; yet many are contained in such great abundance in the rinds of certain fruits, that they may be extracted by simple expression, while others can be obtained only by maceration in a fat or fixed oil.

As we have already said, volatile oils are very easily altered; it is therefore necessary that they should be preserved with great care to keep them in good condition. They ought to be placed, when fresh, in vessels that are well filled, and closely stopped, and kept in the dark. It is equally necessary to be careful to keep them clear; for mucilage acts as in the aromatic waters, although more slowly; that is, it decomposes the small quantity of water which is found in the oil, from which it follows that the essence resinifies itself, and the mucilage spoils itself, while the oil becomes rancid.

Volatile Oils or Essences by Distillation.

The manufacture of volatile oils by distillation requires the use of water at the boiling temperature, as in the case of aromatic waters. This liquid being converted into vapor serves as a vehicle for the oil, which is lighter though less volatile than it is.

The following rules are to be observed for the distillation of volatile oils:—

1. Distill promptly.

2. Divide the material as much as possible to facilitate the escape of the oil contained therein.

3. Operate on large quantities in order to obtain strong products, and to have them of a better quality.

4. Charge the still with water already distilled from the substance, and which consequently contains a certain proportion of volatile oil.

5. Only use a sufficient quantity of water to prevent the materials from being burned, and use the first water that is distilled several times on fresh materials.

6. Saturate the water of the still with common salt, especially for exotic substances, whose oil is heavier than water. By this means, the density of the liquid is increased, and it is compelled to attain a higher temperature before boiling. Ordinary water boils at 100°, salt water requires 106°.

As in the case of aromatic waters, the florentine receiver should be used, and care should be taken that, in the case of the fluid oils, the water on the coil should be frequently renewed; and for those which concrete easily that the temperature is maintained at 30 or 40 degrees.

The distillation of volatile oils is effected better in the turk's-head still than in that with the goose-neck. Besides the temperature is easily regulated, and it is less difficult to cleanse a straight pipe than a crooked one, from the oil that may adhere to it and communicate its odor. Soubeiran's still may be used with advantage.

For the extraction of volatile oils, flowers and plants are generally used when fresh, yet there are some plants which, when dried, produce more oil than when they are fresh; sometimes the latter furnish none at all. Milfoil* and garden balm, for instance, present a remarkable example of this singular phenomenon. This is attributed to the fact that in the fresh plant the oil exists in a peculiar state of combination, which is destroyed by the drying.

* Milfoil. (*Achillea Millefolium*) *Common Yarrow.—Trans.*

Volatile Oils or Esssences by Expression.

Volatile oils are extracted by pressure from those substances which contain them in great quantity, and where these oils are almost on the very surface of the substance. The lemon, orange, cedrat, bergamot, and all similar fruits, contain the essence in the outer rind, or *zeste*, which incloses their acid pulp. To obtain the oil, all of the yellow or green portion of the surface of these fruits is rasped off, and the mass is inclosed in a small hair sack, and subjected to the action of a press between sheets or plates of fine tin; it is allowed to clarify, and is then decanted.

The volatile oil obtained by this process is more fragrant than that extracted by distillation, but it will not keep so long; besides it is impure, and is always clouded, because it is charged with mucilage, and a small proportion of water which is expressed from the rind.

The oils obtained by pressure are yellow, highly odorous, thicken quickly, in time acquire a disagreeable odor, leave a grease spot on cloth, are not entirely soluble in alcohol; while those that are distilled are more fluid, have a less agreeable odor, are more soluble in alcohol, and keep for a long time.

Rectification of Volatile Oils or Essences.

We have already said that volatile oils are altered, and become damaged under certain circumstances. On becoming old, some become entirely thick, while others are so only in part; they become rancid, or lose their odor, and sometimes throw down a deposit which contains a resinous substance; have a consistence and odor similar to turpentine, while the supernatant volatile oil has lost none of its fluidity. This resin is dissolved in the volatile oil when shaken; it does not separate from it again, and greatly hastens its destruction. When the oils of certain seeds have reached this condition of change, they are no longer susceptible of crystallizing by a slight degree of cold as before.

The light volatile oils, like those of lavender, sage,

lemon, &c., experience the changes, of which we have just spoken, more promptly than the heavy volatile oils of cinnamon, cloves, sassafras, &c. It is easy to observe the beginning of the change in volatile oils, by the action of their acids on the corks, which they corrode and stain yellow, as is done by nitric acid.

Volatile oils, which have become rancid, and although very much deteriorated, entirely deprived of their odor and color, and almost without fluidity, are not lost beyond remedy. They may be restored in all their purity, but the ordinary rectification is insufficient, because they are then deprived of all their perfume. We shall now proceed to describe the different methods adopted for their rectification, in order to restore to them all their original properties.

The volatile oil which is to be rectified is placed in a still, along with a large quantity of the recent plant, and a sufficient quantity of water; the distillation is proceeded with. When the volatile oil which has been spoiled by age is rectified, it is saturated anew with the perfume, and passes over with the volatile oil arising from the fresh plant. In this manner the volatile oil is completely renewed.

When a volatile oil is not altogether changed, but has commenced to lose its color and limpidity, it is sufficient, in order to restore it, that it be poured into a small glass retort placed in a sand-bath over a furnace, the receiver attached, and the distillation proceeded with at a moderate heat, about the temperature of boiling water. The volatile oil which passes over is limpid and almost without color. The distillation is suspended as soon as the drops begin to be colored; that which remains in the retort is thick, and has very much the appearance of a resin.

All volatile oils lose considerably by rectification; some about one-third, and others more, according to the state of deterioration in which they are when rectified.

Sophistication of Volatile Oils, and the Means of Detecting the Fraud.

Most of the volatile oils met with in commerce are adulterated. Want of good faith and honesty in certain dealers, who, to increase their profits, make no scruple in cheating the public so long as it requires goods at a *low price*, are the causes which multiply these adulterations. It is therefore important for the liquorist, if he cannot prepare his own oils, at least to know how to detect the fraud.

Almost all the high-priced volatile oils, and those which are sent to foreign countries, are mixed; some with volatile oils of lower price, others with volatile oils of other substances, and which have lost their color by exposure to the air or by age; some with fixed oils, as that of the olive, the almond, &c., and, finally, with alcohol. The following are the means of detecting these frauds :—

Sophistication by fat or fixed Oils.—A volatile oil, which contains a fixed oil, is as much less liquid as the proportion of fat oil is increased; then, when vigorously shaken together, bubbles of air will be observed to collect on the surface of the liquid.

Unsized paper is used to discover the mixture made with a fat oil; one or two drops of the oil examined are let fall on the surface of the paper, and then exposed to the air, or to a gentle heat. If the oil is pure, it is completely volatilized; if it is mixed with a fat oil, it leaves on the paper a permanent spot which renders it transparent.

The adulteration by a fixed oil may also be readily ascertained by distilling the sophisticated oil in a retort over a water-bath. The volatile oil passes over during the distillation, while the fixed oil remains in the retort, because it cannot be converted into vapor at the temperature of boiling water. There is no reason to fear the adulteration of volatile oils by fixed oils, which are put in the still with the plants at the time of their distillation for extracting the essence, because volatile oils begin to boil and are distilled at a temperature much below that which is required for the fixed oils.

Alcohol is also an excellent means for detecting this sophistication. It is sufficient, in applying this test, to place any quantity of the suspected oil in a graduated tube, and to pour on it eight times its bulk of pure alcohol and shake it. The alcohol dissolves the volatile oil, leaving the fixed oil, which falls to the bottom of the tube, where the quantity is indicated to within some hundredths by the graduation.

It quite often happens that a portion of the undissolved fat oil adheres to the sides of the tube, and by so much diminishes the quantity collected at the bottom; in this case it is essential to promote the precipitation by slight blows upon the tube in different directions.

Sophistication by Alcohol.—This fraud alters volatile oils much less than the preceding; it has not, like the fixed oils, the objection of rendering them viscid; it renders them, on the contrary, more fluid, and does not change the color.

The adulteration with alcohol is rendered certain when, on mixing the volatile oil with water, the mixture immediately becomes white and milky, as the alcohol unites with the water and the oil floats on its surface.

The following method determines exactly the quantity of alcohol contained in a volatile oil: A graduated glass tube is filled with water to any height desired, and the same quantity of volatile oil is then added, a portion of the tube, at the top, being left empty. The two liquids are then frequently shaken, and after a moment's rest, if the oil contains alcohol, it will be observed that the volume of the water has increased, while that of the oil has diminished; the graduation on the tube will indicate the proportions of the mixture.

Potassium has the property of promptly demonstrating the presence of alcohol in volatile oils. The following is the process by which the liquorist may apply this reagent successfully. It consists in putting a bit of potassium, as large as a pin-head, into a small quantity of the suspected volatile oil. If the oil contains so much as one-fourth of alcohol at 90 or 96 degrees, the

potassium at once assumes a round form, with a brilliant and shining aspect like a globule of mercury; it moves about, oxidizes very promptly, and disappears in at least one or two minutes; a slight noise always accompanies these phenomena. When the alcohol is only mixed in the proportion of a sixth, an eighth, a twelfth, and even a twentieth, the same phenomena take place; it is only to be observed that the potassium disappears more slowly, and the noise is much less sensible when the proportion of alcohol is less considerable.

Sophistication by Common Volatile Oils.—This fraud, which is more difficult of detection, consists in mixing with certain volatile oils the more common and cheaper oils, such as the rectified oil of turpentine, lavender, rosemary, &c. This adulteration, before which all the tests of chemistry have failed, can be detected only by comparison with an oil of unquestionable purity. It is to be observed, however, that, by saturating a piece of cloth or paper with this sort of mixed oils, the more volatile oil is first dissipated, and that whose odor is most enduring is evaporated last, and may thus be distinguished, that of turpentine easiest of all.

Receipts for the Volatile Oils or Essences.

As for the aromatic waters, the quantity of volatile oils or essences is dependent on the season in which the plants, flowers, seeds, fruits, &c., have been gathered. As to the result, the causes are so various, which may increase or diminish it, that it is impossible to establish any very positive basis; the nature of the soil, exposure, good or bad weather, cause the result to vary in considerable proportions.

The details given, at the beginning of this chapter, render it unnecessary to repeat our observations in reference to the extraction of volatile oils. We shall content ourselves with giving the receipts for the volatile oils of roses and cinnamon, which will serve as types, one for the light, and the other for the heavy oils. We shall also give the receipt for the volatile oil of bitter

almonds, because of the peculiar characteristics presented in its manufacture.

Volatile Oil or Essence of Roses.

Petals of fresh roses . . .	25 kilogrammes.
Water	10 litres.
Common salt	500 grammes.

After fixing the grate in the still, put in the flowers, add the water and salt, adjust the cap, lute the joints of the apparatus, and distill, until the volatile oil ceases to pass over; collect the product as it comes off in a florentine receiver; remove the oil which floats on the aromatic water, with a pipette, filter it if necessary, and preserve it in well-stopped flasks.

There is a particular adulteration of volatile oil of roses, of which we designedly omitted to speak above. Sometimes the oil of roses imported from the East is nothing more than spermaceti dissolved in some fixed oil, to which a small quantity of the pure volatile oil has been added. In this condition the fraudulent mixture presents the appearance of the true oil, and, like it, remains congealed at a temperature of ten degrees above zero.

This fraud is readily detected. When the oil is rendered liquid by a slight increase of temperature, it has neither the fluidity nor mobility of the pure oil of roses; alcohol dissolves only a small portion of it, and it leaves a spot on paper which is not entirely dissipated by heat.

We take the liberty of reproducing an extract from a pamphlet on the subject, published in 1804, by M. Langlès, because it contains some information in regard to the essence of roses which is but little known:—

"Can it be imagined," says this learned Orientalist, "that a process, which is so simple and so wide-spread in the East, and in fact throughout the western coasts of Africa, which is the result of another known from time immemorial (rose water), does not date back more than two hundred years? This opinion differs very much from that of many of the learned."

From his researches among oriental writers, he has ascertained that, prior to the year 1021 of the *Hegira* (1612 of the common era), the essence of roses was entirely unknown.

In a *History of the Great Moguls*, from 1525 to 1677, the discovery of the essence of roses is mentioned in the most positive terms in the two passages which follow :—

"The essence of rose water which the princess (Noùr-Djihân-Beygum) at first named *Djihânguyr's essence*, as well as some other perfumes of less price, the enjoyment of which she obtained for people less favored by fortune, is the invention of herself and her mother.

"At the beginning of the perfumed feast of the new year, and the commencement of the reign of Djihânguyr, the mother of the Princess Noùr-Djihân presented her with some of the essence of rose-water which she had extracted, and the prince, having found it agreeable, thought proper to add his august name to this discovery, and he called it *à ther djihânguyry*, that is, Djihanguyr's essence.

"The method of making the *à ther*, or *attar*, says Gladwin, in a *History of Hindoostan*, was first discovered by the mother of Noùr-Djihân-Beygum. The *attar* is the essential oil of roses, which floats in very small quantity on the surface of distilled rose-water," &c.

The following account of the discovery is given by the Venetian, Manucci, who sojourned forty years in the Indies :—

"While the Emperor was walking with her (Noùr-Djihân-Beygum) on the border of a canal filled with rose-water, they perceived a sort of foam which had formed on the water and floated on its surface. They waited to collect it when it should come to the shore, and they then ascertained that it was a substance which had been extracted from the roses by the action of the sun, and had collected together in one mass. The whole seraglio agreed in pronouncing this the most delicate perfume known in India. Eventually, art attempted to

imitate what had been produced by chance and by nature."

[NOTE.—The following article, from Ure's Dictionary, may not be uninteresting to the reader, and is therefore inserted here without apology.—*Trans.*

"The *oil of roses*, called also the *attar* or *otto*, is extracted by distillation from the petals of the *rosa centifolia* and *semper virens*. Our native roses furnish such small quantities of the oil, that they are not worth distilling for the purpose. The best way of operating is to return the water repeatedly on fresh petals, and eventually to cool the saturated water with ice, whereby a little butyraceous oil is deposited. But the oil thus obtained has not a very agreeable odor, being injured by the action of the air in the repeated distillations. In the East Indies the attar is obtained by stratifying the roses in earthen pans, in alternate layers, with the oleiferous seeds of a species of digitalis, called *gengeli*, for several days, in a cool situation. The fat oil of the seeds absorbs the essential oil of the rose. By repeating this process with fresh leaves and the same seed, they become eventually swollen, and, being then expressed, furnish the oil. The turbid liquid thus obtained is left at rest, in well closed vessels, where it gets clarified. The layer of oil which floats on top is then drawn off by a capillary cotton wick, and subjected to distillation, whereby the volatile oil is separated from the fat seed oil."]

Volatile Oil or Essence of Cinnamon.

Ceylon cinnamon, bruised . .	5 kilogrammes.
Water	20 litres.
Common salt	1 kilogramme.

Macerate for twenty-four hours, add the salt, and distill until the water passes over clear. The product will be milky, very aromatic, and by rest will yield a volatile oil at the bottom of the receiver; after twenty-four hours, decant the product, return it upon the materials remaining in the still, and distill as at first; repeat this operation until there is no longer any perceptible

increase of the oily product, allow it to rest twenty-four hours, and decant to separate the volatile oil.

Volatile Oil, or Essence of Bitter Almonds.

Bitter almonds	10 kilogrammes.
Water	a sufficient quantity.
Common salt	1 kilogramme.

Reduce the almonds to a powder by a peculiar mill, and extract the fixed oil by pressure in the usual way; that is to say, by a stamping press; mix the almond cake with water so as to form a thin broth, introduce the mixture into a still, and allow it to macerate for twenty-four hours; then distill by the aid of steam, which is injected through a tube into the still, or by means of Soubeiran's apparatus; in this last case the diluted almond cake should be placed in the water-bath. Continue the distillation so long as the product is odorous.

Then separate the volatile oil from the aromatic water, pour this into a small still and distill anew; a new quantity of essence, which passes over at the beginning of the operation, will be separated; this essence must then be mixed with the first product.

For a long time the formation of the volatile oil of bitter almonds was an enigma to chemists, which they had almost despaired of solving; they asked themselves whence this essence could have originated, since the bitter almond contains only a fat oil, and other principles that are completely inodorous. MM. Robiquet, Liebig, Bussy, and Fremy have taught us that it is the product of a metamorphosis, of a chemical reaction which is established, under the influence of water, between the vegetable albumen of the almonds and one of the inodorous principles which accompany it. This principle, which is called *amygdaline*, is white, crystalline, sweetish, and soluble.

If, in fact, amygdaline is brought in contact with a solution of the albumen of almonds, or, more simply, with an emulsion of sweet almonds, the mixture almost immediately acquires a strongly aromatic odor. 100 parts

of amygdaline will thus furnish by distillation as much as 42 parts of essence, accompanied by five or six parts of prussic acid. And what is more remarkable, is, that this conversion of an inodorous into a highly odorous principle is effected only by the albumen of the bitter almonds, and never by that of other vegetables, nor by the albumen of animals. Moreover, what thoroughly proves that the essential oil in this case is formed at the expense of the amygdaline, is, that sweet almonds, which do not contain amygdaline, do not yield the slightest trace of essential oil by distillation.

Because of this peculiar property of the albumen of the bitter almond, which is very similar to diastase, or a ferment, it is distinguished by the name, *synaptase.*

When exposed to the air, the essential oil of bitter almonds absorbs oxygen, and deposits crystals of benzoic acid. It contains from 8 to 14 per cent. of prussic acid, which adheres to it obstinately, but from which it may be separated by distilling it upon potassa. When entirely freed of this acid, it is no more poisonous than other volatile oils, and is classed with them.

Generally, the essence of bitter almonds found in the market, whether for liqueurs or perfumery, is composed of one part of the pure volatile oil of bitter almonds and seven parts of rectified alcohol.

For some years, there has been employed, in perfumery for scenting soaps, a chemical product having a perfume almost identical with that of the essence of bitter almonds; it is called *essence of mirbane.* The following is the method of preparing it:—

Benzine	2 kilogrammes.
Nitric acid, at 40°	2 "
Sulphuric acid, at 66° . . .	2 "

Pour the benzine into a large matrass; add gently, and in small doses, the acids, which are mixed at the moment of being used (a sunny day should be selected for this operation), shake the mixture carefully every fifteen minutes for four hours; it results in an elevation of

temperature and the abundant evolution of nitrous acid gas, which continues throughout the operation.

After a rest of ten or twelve hours, decant the oil which floats on the acids, and wash it in many waters.

Thus prepared, the *essence of mirbane* is of a yellow color and very liquid, and has a powerful and highly aromatic odor. It cannot be used in the manufacture of liqueurs.

Table of Volatile Oils or Essences susceptible of being used by the Distilling Liquorist.

	Names of oils.	Substances which yield them.	Country producing them.	Color of the volatile oil.	Odor of the volatile oil.	Weight as compared with water.	Remarks.
1	Absinthe (large)	Entire plant (fresh)	South of France and environs of Paris	Decided green	Of the plant	Lighter	Very odorous; becomes dark and thick by age.
2	Absinthe (small)	" "	" " "	Green	" "	"	Less odorous than the above.
3	Maritime absinthe	Dried stalks	Sea-coast	Amber	Absinthe & camphor	"	But little used.
4	Bitter almonds	Almond cake	South of France	Bright yellow	Prussic acid	Heavier	Very volatile; crystallizable; contains much prussic acid, of which a few drops will kill a dog.
5	Angelica	Dried roots	Forests of the South	Golden yellow	Slight musky odor of angelica	Lighter	Very odorous; darkens by age.
6	Angelica	Entire plant (fresh)	Cultivated in gardens	Bright yellow	Of the plant	"	Less odorous than the last.
7	Dill (Anethum)	Dry seeds	France and Germany	Colorless	" "	"	Very fluid, and more odorous than that from fresh seeds.
8	Anise	" "	South of France	Almost colorless	Sweet and aromatic of the seeds	"	Crystallizes at 12° C., and easily becomes rancid.
9	Elecampane (Inula)	Dried roots	Moist woods & gardens	Bright yellow	Slightly of camphor	"	Crystallizes easily, and then becomes white.
10	Star Anise	Dry seeds	China	Colorless	Sweet anise	"	Becomes yel. by age; crystallizes at 15°C.
11	Sweet Basil	Dried plant	Cultivated in gardens	Golden yellow	Perfect of the plant	"	Becomes darker by age.
12	Mint	" "	" " "	" "	Musky, having some relation to peppermint	"	The fresh stalks obtained before, during, or after flowering yield no essence.
13	Bergamot (distilled)	Fresh rind	Italy, South of France	Almost colorless	Agreeable of fruit	"	Perfume fragrant and odorous.
14	" (expressed)	" "	" " "	Yellow	Of the fruit	"	Perfume less pleasant than the last.
15	Bigarades (distill'd)	*See* Curacoa					
16	Botrys	Dried leaves	Environs of Paris	Bright yellow	Strongly of the plant	"	Taste bitter and somewhat acrid.
17	Calamint	Fresh plant in flower	Stony mountains of the South	" "	Recalls the odor of garden mint	"	Taste acrid.
18	Calamus	Dried roots	Brittany & Normandy	" "	Feebly of camphor	"	Taste of camphor.
19	Chamomile	Fresh flowers	France and Roman States	Beautiful blue, limpid	Agreeable, of the flower	"	The dried flowers yield a much less aromatic oil.
20	Cinnamon (Ceylon)	Dried bark	East Indies	Dark yellow	Approaches the odor of a chinch	Heavier	Perfume superior to that of China cinnamon or cassia.
21	" Chinese (Cassia)	" "	China	" "	" " "	"	Perfume inferior to the last.
22	Carraway	Dry seeds	Fields and gardens in France	Bright yellow	Cumin	Lighter	Crystallizes at 12°; becomes rancid by age.
23	Cardamom (greater)	Dried fruit	East Indies	" "	Pimento	"	Taste sharp and penetrating.
24	Cardamom (less)	" "	" "	Yellow	Pimento, but stronger	"	" " " "

	Names of oils.	Substances which yield them.	Country producing them.	Color of the volatile oil.	Odor of the volatile oil.	Weight as compared with water.	Remarks.
25	Carrot	Dry seeds	France	Yellow	Balsam of Peru	Lighter	Liquid, hot and biting.
26	Cascarilla	Dried bark	South America	Light greenish	Musky	“	Very fluid; taste acrid and biting.
27	Cedrat (distilled)	Fresh rind	Italy, Portugal, and South of France	Yellow	Agreeable of the fruit	“	Very odorous and agreeable.
28	Cedrat (expressed)	“ “	“ “ “	“	“ “ “	“	“ “ “ “
29	Celery	Dry seeds	France	Reddish-brown	The plant	Heavier	Very odorous and sharp.
30	Chervi (*Sium Sesarum*)	“ “	“	Yellowish	Parsnip seeds	Lighter	Darkens and thickens by age.
31	Citron (Lemon) (distilled)	Fresh rinds	Italy, Portugal, and South of France	Almost white	Agreeable of the fruit	“	Darkens by age with a lemon-white deposit which it is necessary to separate to prevent total decomposition.
32	Citron (expressed)	“ “	“ “ “	Bright yellow	“ “ “	“	
33	Coriander	Dry seeds	France	“ “	Strongly of the seeds	“	Reddens by growing old.
34	Cumin	“ “	Germany	“ “	“ “ “	“	Acid, taste acrid.
35	Curacoa	Dried rind of bitter orange (bigarade)	Italy, Portugal, and South of France	“ “	Feeble but agreeable of fruit	“	Taste bitter.
36	Dittany (of Crete)	Dried plant	Greece	Yellow	Approaches origanum	“	Liquid, acrid and biting.
37	Fennel	Dry seeds	South of France	Bright yellow	Aromatic of the seeds	“	Crystallizes at 6° C.
38	Fennel (Florentine)	“ “	Italy	“ “	“ “ “	“	“ “ “
39	Cloves	Dried buds	East Indies	Deep yellow	Strong of cloves	Heavier	Becomes dark and thickens by age; taste sharp and burning.
40	Ginger	Dried roots	Antilles	Greenish-yellow	Faint odor of the root	Lighter	Taste bitter and sharp.
41	Hyssop	Fresh flowering plants	South of France	Bright yellow	Perfect of plant	“	Very odorous; acrid.
42	Juniper	Fresh berries	North of Europe	Deep yellow	Strong of berry, similar to turpentine	“	Color deepens and it thickens with age.
43	Laurel (Bay)	Fresh leaves	South of France	Greenish-yellow	Decided of leaf	“	Color deepens by age.
44	Lavender	Fresh flowering plant	France	“ “	Of the plant	“	“ “ “
45	Limes	Fresh rind	Italy	Bright yellow	Lemon-like	“	Perfume very aromatic.
46	Mace	Dried arillus of the nutmeg (*Mace*)	Moluccas	Golden yellow	Pepper and thyme	Heavier	Taste peppery.
47	Marjoram	Fresh flowering plant	South of France	Bright yellow	Feeble odor of mint and camphor.	Lighter	Darkens by age.
48	Melisse (*Balm*)	“ “	Cultivated in gardens	Almost white	Lemon-like	“	Darkens by age; taste acrid.
49	Milfoil	Flowering plant dried	France	Bright blue or yellowish-green	Aromatic, camphor-like	“	Deepens to a decided green by age; fresh plant yields no oil.

	Names of oils.	Substances which yield them.	Country producing them.	Color of the volatile oil.	Odor of the volatile oil.	Weight as compared with water.	Remarks.
50	Neroli	Fresh orange flowers	France	Reddish-yellow	Pleasant, of orange flowers	Lighter	Reddens and browns by age: the best is made from the flowers of the bitter orange (*Bigarade*).
51	Nutmeg	Dried nutmegs	Moluccas	Yellow	Faint odor of nutmeg	Heavier	Composed of two oils, one fluid and light, the other thick, white, and heavier than water.
52	Orange	*See* Portugal					
53	Orange flowers	*See* Neroli					
54	Parsely	Dried seeds	France	Greenish-yellow	Of plant	"	Taste strong and bitter.
55	Origanum	Fresh flowering plants	South of France	Brownish-yellow	Of plant, but somewhat pepper-like	Lighter	Taste acrid; darkens by age.
56	Peppermint	Fresh flowering tops	England, United States	Colorless	Of plant	"	Taste very sharp; crystallizes at 22° in fine needles; yellow by age.
57	Portugal (distilled)	Orange rind	South of Europe	Almost white	Pleasant, of oranges	"	Perfume less than by pressure.
58	" (expressed)	" "	" " "	Yellow	" " "	"	Becomes rancid easily, deposits a mucilage which must be removed to prevent decomposition.
59	Petit-grain	*See* Bigarades					
60	Rhodium (Rose-wood)	Dried wood	Grecian Archipelago and Antilles	"	Of roses and sassafras	"	Taste bitter; reddens by age.
61	Rosemary	Fresh flowering	South of France	Greenish-yellow	Of plant, camphor-like	"	Taste burning; darkens by age.
62	Roses	Petals of 100-leafed Rose (*Rosa Centifolia*)	South of France and East Indies	Colorless or lemon	Strong of roses	"	Crystallizes below 10°.
63	Rue	Fresh plant	France	Green & yellowish	Of plant	"	Odor strong and disagreeable; taste acrid.
64	Saffron	Dried stigmata of the saffron	Gatinais	Golden yellow	Of saffron	Heavier	Taste acrid and burning; changes into a white substance which floats on water.
65	Sage	Fresh plant	France	Greenish-yellow	Camphory, decided of plant	Lighter	*Salvia officinalis* yields a more aromatic essence than the *Salvia sclavea*; darkens by age.
66	Sassafras	Dried roots	America	Reddish-yellow	Pleasant, of the plant	Heavier	Heavier than any other volatile oil; reddens by age.
67	Serpyllum (*Wild Thyme*)	Fresh flowering plant	Forests of France	Yellow	Aromatic, of plant	Lighter	Darkens and browns by age.
68	Tansy	" "	France	Greenish-yellow	Of plant, approaching fennel	"	Taste of anise, and piquant.
69	Thyme	" "	South of France	Yellow	Strong and pleasant of plant	"	Darkens and browns by age.
70	Zedoary	Dried roots	East Indies	Bright yellow	Of the root, camphorish	Heavier	Darkens by age.

Volatile Oils by Maceration, or Extracts.

Volatile oils are obtained from certain flowers by *macerating them in a fixed oil* (*enfleurage*), and then bringing this in contact with alcohol; the product of this operation is called an *extract.*

Flowers, whose odor is very fugitive, do not yield a volatile oil by expression or distillation, such as *white hawthorn* (*Mespilus oxyacantha*), *cassie* (*acacia farnesiana*), *honeysuckle* (*Lonicera periclymenum*), *geranium*, *jasmine*, *jonquil*, *heliotrope*, *hyacinth*, *lilac*, *lily*, *muguet*, *narcissus*, *patchouli*, *reseda* (*mignonette*), *syringa*, *tuberose*, *violet*, &c. &c. The *aroma* can be extracted only by the use of a fat or fixed oil (as that of olive, ben, or sweet almonds) as a solvent.

The flowers are separated from the stalks, and placed in layers or strata, with cotton wool, or white woollen cloths saturated with oil between each layer; after three or four days, the flowers are renewed, and this operation is repeated until the oil, absorbed by the cotton or cloth, has imbibed a sufficient quantity of the odor. The cotton wool, or woollen cloths are then digested in alcohol at 85 or 90 degrees, and distilled in a water-bath. The alcohol takes up the odor, and thus forms the volatile oil or *extract.*

Some manufacturers prefer not to use the still. In order to obtain the volatile oil of a flower, they only place the oil expressed from the cotton wool, or cloth, in contact with alcohol for some days; the latter dissolves the volatile oil without disturbing the fixed oil. After decantation, the spirit is filtered.

In order to accomplish the decanting more effectually, the mixture may be exposed to frost, or to the action of an artificial freezing mixture. The oil solidifies, and falls to the bottom of the vessel, while the alcohol floats above charged with the odorous principle of the flower. It is decanted without distillation.

There is a fourth process proposed by a skilful perfumer of Paris, M. Teissier-Prevost, which consists in replacing the oil by mucilage of gum arabic, with which a number

of bats of cotton are saturated, and above and under which is placed a layer of flowers; when the mucilage is properly impregnated with the odorous principle of the flowers, it is slightly pressed. The mucilage, saturated with the volatile oil, is then treated with alcohol, which takes up the oil and precipitates the gum, which may continue to be used indefinitely. This process is more economical, because mucilage is much cheaper than the various fixed oils employed up to the present time, and is moreover not changed by the operation.

Other substances, such as the iris and vanilla, yield no volatile oil, either by distillation, maceration, or expression; their perfume can only be extracted by successive infusions in alcohol.

CHAPTER XVIII.

SUGAR.

SUGAR is one of the essentials for the production of liqueurs; it is therefore important for the liquorist to be thoroughly acquainted with the nature, characteristics, and methods of its classification.

Chemically, sugar is a substance which, when dissolved, and placed in contact with a ferment, has the property of being converted into alcohol and carbonic acid; composed entirely of oxygen, carbon, and hydrogen, it may be considered as a *vegetable oxide;* according to Gay Lussac and Thénard, sugar consists, by weight, of 42.47 parts of carbon, 50.73 parts of oxygen, and 6.90 parts of hydrogen.

Two principal varieties of sugar are recognized, viz.: common or crystallizable sugar and uncrystallizable sugar.

The former, produced generally from the sugar-cane and beet, is also found in the sap of the maple, the carrot, pumpkin, &c.; the latter is met with in the grape,

pear, potato, and a great number of fruits, vegetables, and seeds.

Sugar, suitable for the use of the liquorist, is obtained exclusively from cane and beets. It is found in the market under three different forms: *brown*, *clayed*, and *refined* sugar.

Cane and beet sugar are absolutely identical, and do not differ one from the other when refined to the same degree of purity. The taste, crystallization, color, and weight are the same. It is the result of habit or ignorance to assert the contrary.

When in a state of purity, sugar is white, crystallized, shining, and hard, of a very sweet taste, phosphorescent when struck together in the dark, unalterable when exposed to a dry atmosphere, and very soluble in water. At the ordinary temperature, water dissolves its own weight; but at the boiling point it dissolves it in all proportions.

The taste of sugar is sensibly modified by rasping and pulverizing. That which is very hard exhibits this phenomenon in the highest degree. It appears that the force applied by the pestle or the rasp, raises the temperature sufficiently to establish the commencement of carbonization, which communicates to it a slight empyreumatic flavor.

Sugar is soluble in alcohol only to a limited extent. When heated dry, it liquefies, becomes discolored, and is converted into caramel. Hydrochloric, nitric, and sulphuric acids added to a boiling solution of sugar, render it uncrystallizable. Long-continued ebullition produces the same effect as the acids; but it is necessary to continue this operation more than eighteen hours, while most frequently a few minutes are sufficient when the acids are used.

The uses of sugar as an alimentary substance and a condiment are so numerous and so well known, that it is useless to refer to them.

Sugar in large, brilliant crystals, with very smooth faces and angles, is called *sugar-candy*. There are three varieties, the *white*, *straw-colored*, and *red*. White candy

is without odor, and is sugar in a state of absolute purity.

Molasses is the residuum from the manufacture and refining of sugars; it is a dense, viscous, uncrystallizable syrup, marking from 41 to 44 degrees on the areometer of Baumé (*pese-sirop*). It is a deep yellow, a bright brown, or almost black, according to the source from which it is obtained. It contains from 40 to 50 per cent. of its weight in crystallizable and 12 or 15 per cent. of uncrystallizable sugar.

Molasses from the cane is not identical with that from the beet; the former is infinitely superior. Sugar-house molasses is inferior to that obtained from the refineries.

Glucose.

Among the uncrystallizable sugars, glucose occupies the foremost place. This natural product of vegetation is met with in a great number of fruits which present an acid reaction, in honey, and *diabetic urine*. Under some influences many vegetable substances, especially grain and potato starch and gum, are susceptible of conversion into this kind of sugar.

We will take a hasty glance at the different forms in which glucose is met with.

Grape Sugar.—This abounds in the grape, and in all saccharine fruits; it may be separated as follows: An excess of chalk, or, what is better, marble dust, is poured into the must of the grape. This calcareous salt saturates the acid tartrate of potash which exists in the grape juice; effervescence takes place, accompanied by the escape of carbonic acid, which aids in the agitation. The saturated liquid is immediately clarified with the white of eggs, or bullock's blood; then it is evaporated until, while boiling, it marks 35 degrees, and is allowed to cool. After some days, it forms a granular mass, which is drained and carefully washed with cold water, and submitted to a strong pressure.

Grape sugar occurs only in the form of small whitish grains of little consistency and grouped together in little

nodules; its taste is fresh yet sweet, but not so much so as common sugar. It requires two and a half parts of grape sugar to communicate the same degree of sweetness to a given quantity of water, as that produced by one part of cane sugar; it is less soluble in water than the latter at the ordinary temperature. Boiling alcohol dissolves it readily, and, when cold, precipitates it in small white nodules. These characteristics distinguish it from cane sugar, all the chemical properties of which it has. It is composed of carbon, 36.71; oxygen, 56.51; hydrogen, 6.78.

Grape Syrup.—This syrup is obtained by the same process as grape sugar, the evaporation being continued only until the syrup has attained 31 degrees.

Grape syrup is used with much success in improving brandies, especially reduced troix-six.

Sugar from Potato Starch.—This substance was discovered in 1812, by Kirchkoff, by treating starch with dilute sulphuric acid. This sugar is in its nature absolutely like that obtained from grapes and other saccharine fruits. The following is the simplest process for preparing it: Twelve kilogrammes of potato starch are mixed in forty litres of water, acidulated with 200 grammes of sulphuric acid. The mixture is boiled in a vessel which is not attacked by sulphuric acid, as a pan lined with lead; during the first hour of the ebullition it is constantly stirred. The mass then becomes more liquid, and no longer requires constant stirring. The water must be replaced as it evaporates. When the liquid has been boiled sufficiently (seven or eight hours), chalk or Spanish whiting (carbonate of lime) must be added to neutralize the acid; it is clarified with charcoal, white of eggs, or bullock's blood, and filtered through a woollen bag. The liquid is evaporated to the consistence of syrup. On cooling, it deposits a considerable proportion of sulphate of lime. The liquid is decanted, and the operation completed by concentrating it to 40 or 41 degrees; then it is poured into coolers where the change is allowed to begin; finally,

the thick syrup is poured into hogsheads, where the solidification is finished.

Many vegetable substances, when treated like starch, with water acidulated by sulphuric acid, yield similar sugar. Thus it may be prepared from woody fibre when separated from all foreign substances, as, for example, paper and linen rags.

Syrup from Potato Starch.—The syrup of starch is a solution of saccharified starch, but not concentrated; it is obtained by the same process as the preceding sugar, using, however, less acid, and boiling for a shorter time.

White Syrups are filtered through *animal charcoal* (bone black) in grains; then evaporated to 32° when hot; when cold they should weigh 36°, be very white, and have a sweet taste, and be free from any unpleasant flavor.

It is readily ascertained if a syrup of starch has been badly prepared; that is to say, if it still contains starch, by pouring a small quantity of the syrup into a wine-glass and adding a drop of the *tincture of iodine*, which instantly produces a violet color. A syrup of starch containing a certain quantity of sulphuric acid, in consequence of incomplete saturation, is recognized by means of litmus paper, which, by contact with the acid, becomes instantly a bright red.

White syrups are used by liquorists and confectioners for a great many purposes, especially for liqueurs and cooling drinks.

Colored Syrups are used in the breweries for simple beers, or for the manufacture of common caramels. They are also employed for glazing.

Syrup of Grain Starch.—This is obtained by the same process as the syrup of potato starch, by substituting grain starch. Its properties and application are the same as the syrup of starch from potatoes.

Syrup of Wheat.—For many years there has been in the market a product bearing this name; in principle this syrup should be prepared from grain either by means of wheat starch or some other; but this is not always the case. The syrup of wheat is most usually nothing but a very thick white syrup from potato starch,

the decomposition of which is incomplete; that is to say, which contains a notable proportion of dextrine and very little sugar. The presence of dextrine is recognized by pouring some syrup into a small vial; then add the same quantity of alcohol at 85°, and shake well; the liquid will become milky, and a glutinous insoluble mass will be found adhering to the bottom and sides of the vial if dextrine is present.

The true syrup of wheat, as sold at present, is an extremely thick white liquid, but almost devoid of saccharine matter. The syrup of potato starch of good quality should always be preferred.

There are other varieties of non-crystallizable sugar, such as *honey*, *levulose* or *liquid sugar*, *mannite*, and *glycyrrhizine*. We shall give a short sketch of each of them.

Honey.—This substance is not a distinct species of sugar. It is a mixture of crystallizable with grape sugar, and an uncrystallizable sugar analogous to molasses, accompanied by a peculiar but variable aromatic principle. When honey is not altogether pure it contains, among the rest, wax, an acid, mannite, and even a vegeto-animal substance which communicates to it the property of spontaneous putrefaction. This last is the substance which forms the cells in which the bees deposit their eggs.

By age, honey ferments easily, is discolored, and acquires a sharp taste. Sometimes fermented honeys are found in the market to which consistency and whiteness have been imparted by the addition of flour or starch. This fraud is easily detected by the deposition of the adulterating material when the honey is mixed with cold water, and by the blue color caused by the addition of tincture of iodine to the deposit.

Honey cannot be used in liqueurs on account of its high price; it has also the inconvenience of depositing in the course of time a granular substance which consists of mannite and wax.

Levulose or Liquid Sugar.—This is found in all acid fruits, especially in apples, pears, honey, in the nectar of flowers, in the juice of the onion, &c. For a long

time it was supposed that *liquid sugar* was nothing but glucose associated with foreign substances, such as albumen, gum, soluble salts, and free acids, which prevented its solidification and crystallization; but the experiments of M. Biot have demonstrated that it differs essentially from both glucose and crystallizable sugar. This is the dense uncrystallizable substance which Deyeux called *mucoso-saccharine principle*. It consists of a liquid which cannot be converted into ordinary sugar; after a long time, however, it is changed into nodules of grape sugar.

Levulose is produced when prismatic sugar is under the influence of acids and may be produced artificially by the action of the latter on ordinary sugar; it constitutes in great measure the molasses obtained in the treatment of cane and beet juice in the manufacture of sugar. It is distinguishable from prismatic sugar by being very alterable under the action of alkalies, and from glucose by being very alterable under the influence of water and dilute acids.

Mannite.—A saccharine substance which forms a constituent part of manna. It is met with in the mushroom, couch-grass, celery, and in many vegetable exudations.

Mannite is white, crystallized in small needles, and of a pleasant and sweet taste. It is unalterable in the air; very soluble in cold water; soluble in hot alcohol, from which it is partially precipitated on cooling.

Glycyrrhizine, or Saccharine Matter of Liquorice.—This peculiar sugar, very different from the preceding, is obtained by making a saturated infusion or decoction of liquorice root, and after it becomes cold, adding a small quantity of sulphuric acid; a transparent gelatinous precipitate is formed, consisting of the saccharine matter and the acid. When this precipitate has been collected and washed with cold water, it is dissolved in alcohol, and the acid saturated by carbonate of soda. The sulphate of soda is precipitated and the saccharine matter remains in solution in the alcohol.

When pure, glycyrrhizine is a yellow transparent mass, of a pleasant sweet taste, similar to that of the root from which it was obtained; it is non-crystallizable and with-

out odor. The properties of the *extract of liquorice* are due to this species of sugar.

NOTE.—We would advise our readers, in order to facilitate the dissolving of sugar in the preparation of highly saccharine liqueurs, to use one litre of glucose to each hectolitre of the liqueur. It prevents the sugar from candying. Account must be taken of this addition in calculating the quantity of sugar employed.

CHAPTER XIX.

SUGAR (CONTINUED).

Clarification of Sugar.

THE object of this operation is to separate from the sugar while in a liquid state or syrup, all foreign substances which may disturb its transparency, or which may cause or accelerate its fermentation; it is based upon the property possessed by albumen, of coagulating under the influence of heat, and forming a sort of network which envelopes the foreign substances suspended in the liquid, collects them together, and brings them to the surface in the form of a scum which hardens by cooling, and which has enough consistency to permit its being easily removed.

The following is the method of clarifying *brown* sugars: Place in an untinned copper pan of sufficient size, 50 kilogrammes of good brown sugar, add twenty litres of pure water, and six litres of albumenized water; stir the whole well with a wooden paddle in order to melt the sugar and prevent its attaching itself to the bottom of the pan; light the fire and push it actively. When the sugar boils and begins to rise, pour in, from a height, one litre of albumenized water; this will cause the sugar to fall only to rise again; pour in again a like quantity of the same water and check the fire by closing the ash-pit door. The syrup falls entirely, the scum acquires more consistence and is removed by a skimmer,

then open the ash-pit door to revive the fire; keep up a well-sustained state of ebullition in order that the bubbles may burst on one side, and the new scum be removed from the other side of the pan. When at last the syrup only yields a very light whitish foam, and is become sufficiently transparent, and the bottom of the pan can be seen, it is passed through a blanket or felt bag. If, however, the syrup is not boiled enough it must be left on the fire until it has acquired the proper degree of density. If it has been boiled too much, and marks a point above 31°, it will be necessary to dilute it by the addition of water until it is reduced to this degree.

Albumenized water is prepared as follows: Take the whites of six or eight fresh eggs for 50 kilogrammes of brown sugar, according to the size of the eggs; put them in a pan along with the shells, and add one litre of water, then beat the whole together with a whip or egg beater, and add, in repeated doses, seven litres of water, in order to have the whole form eight litres of albumenized water.

By at once pouring one litre of water on the whites, they are prevented from being beaten up into a froth. It will be observed that we pour three-fourths of the albumenized water into the sugar before heating it. Experience has taught us that the white of eggs coagulates between 50 and 60 degrees Centigrade, and that, when the albumenized water is added at the moment of the ebullition, the clarification is only partial or incomplete. In order not to injure the operation, the syrup should not be stirred with the skimmer during the clarification and even so long as it may be tepid.

There are some brown sugars which, in consequence of being damaged, have become viscous, and are consequently very difficult to clarify. It is proper, under such circumstances, to add about ten grammes of acetic acid (radical vinegar), or, if it is preferred, some litres of lime-water. This water is prepared by placing some quicklime in a wooden bucket, and adding water and stirring with a wooden spatula until the lime is entirely mixed; when the bucket is full, time is given for the water to become clear before using it.

Acetic acid and lime-water serve to cleanse the melted sugar, and facilitate the separation of the foreign substances which it may contain.

Bullock's blood is also employed in the clarification of sugar, but it frequently communicates a bad flavor and repulsive odor, in consequence of the difficulty of procuring the blood fresh. The whites of eggs are to be preferred.

Refined sugars are clarified in the same manner, except that the number of eggs is reduced one-half. The beautiful white sugars are so well clarified at present in the refineries, that they require nothing but pure water for their clarification.

The skimmings and water, in which the utensils are washed, are put in a bucket kept for that purpose; they still contain an appreciable quantity of sugar, and must be clarified together. For this purpose, they are put into a pan with very nearly the same volume of water, stirred strongly with a wooden paddle, and heated to the boiling point; when it begins to boil, the fire is drawn from beneath the pan, and it is left at rest for half an hour before it is skimmed; the fire is then rekindled, and, after it boils up again, the liquid is passed through a woollen strainer, or bag. This syrup may, if it is thought proper, be evaporated to a more concentrated degree, or it may replace a portion of water in a second clarification.

Decolorizing Sugar.

For many years, in consequence of the great fall in the price of sugar, liquorists have preferred to use white sugars rather than brown, and have in a measure given up the practice of decolorizing their sugars. We consider it, however, our duty to describe the process.

When it is desired to clarify, and at the same time decolorize sugars which are deficient in whiteness, we proceed as follows:—

Sugar	50 kilogrammes.
Water	30 litres.
Animal charcoal, purified and in coarse powder	2 kilogrammes.
Wood charcoal in powder . .	1 "
White of eggs, number . .	4

Mix the eggs in a portion of the water indicated, break the sugar in pieces of medium size, place them in a copper pan, add the pure water and the albumenized water, reserving two litres of the latter to be used during the clarification; heat promptly, stirring continually with a wooden spatula until the whole of the sugar is melted; then, while the stirring is continued, add the animal and wood charcoal. When the syrup boils, add the reserved albumenized water in two or three doses, give a last boiling, and draw the whole from the fire. After a short rest, remove the skimmings, and pour the syrup through a woollen bag.

The first portion of syrup which passes is turbid, and contains the finely divided charcoal; it is necessary to return it to the filter, taking care to cover it well in order to prevent the loss of heat, which, by rendering the syrup less fluid, will hinder the filtration. Receive the perfectly clear syrup in a clean vessel.

When the syrup has passed through, wash the charcoal, which is contained in the bag, with boiling water; collect the washings, and put them along with the skimmings.

Animal black is purified as follows: Two kilogrammes of bone-black are placed in a stone jug, and enough water added to form a paste; this paste is washed with 250 grammes of concentrated hydrochloric acid; it is stirred in order that the mixture may be complete, the vessel is refilled with boiling water, it is left to rest for a moment, and the supernatant liquid poured off; this washing is repeated four or five times, and the charcoal well drained.

The process for clarification and decolorizing, which we have just described, yields limpid syrups, the flavor

of which is improved by the use of wood charcoal. The effect of the animal black is to decolorize the syrup.

We would advise the liquorist to use Dumont's filter, with animal black in grains, as the best process for decolorizing syrups.

When it is desired to filter a syrup, the small diaphragm is placed in the bottom of the filter, supported by its four feet, above the stopcock, and the orifice of the air-tube; on this diaphragm is spread a somewhat open cloth, moistened, and slightly stretched, on this is placed the animal black, in grains about the size of *blasting powder* (freed from dust and previously moistened with about one-sixth of its weight of water), so as to fill the filter uniformly; each layer, of about eight centimeters, is smoothed over and lightly packed by means of a sort of trowel, and the process of packing is continued in the same way until the animal black occupies a height of about 36 centimeters.

The first layer of black placed on the cloth should not be more than three centimeters thick, in order that it may be packed more evenly and firmly. When the filter is filled to the height of 36 centimeters, the surface of the black is covered by a clean cloth, also moistened and stretched, and the second diaphragm; then the syrup is poured, as nearly as may be, on the middle, until it stands at the height of about eight centimeters in the vacant space above the black. By this arrangement, the black is not disturbed by pouring in the syrup, and there is no reason to fear the formation of channels through which the syrup will flow too freely. The syrup, by penetrating the various strata of black, displaces the water with which it was moistened, and it is drawn off by the cock; this is separated to be rejected until it is found to be sweet, and is then replaced by the syrup, which very soon flows off in an uninterrupted stream, which is kept up by a constant renewal of the supply as it flows away, being careful to keep the filter full to the top while the batch of syrup holds out.

If the black is not previously moistened with water, the syrup will find difficulty in being absorbed equally;

it may pass more freely through one part than another of the mass, and the filtration will progress irregularly. Under these circumstances, the water produces yet another advantageous effect when animal black is used, which is to effect, at least, a partial lixiviation, as may be ascertained by the saline taste of the water as it flows from the filter.

We should observe that, as limpidity of syrups is an essential condition in order that the filtration and decolorizing may be conducted to the best advantage, it is important to clarify the syrups in advance, as has already been described for brown sugars.

The grains of the animal black should be more or less fine, according to the density of the syrup to be filtered. Thus, the liquorist being under the necessity of diluting with water the alcohol he uses for his common liqueurs, will use for 50 kilogrammes of sugar, 40 or 50 litres of water; he may then filter through a finer black, and procure a more beautiful decolorizing. In any event, the economy of animal black will always indicate its use. It is the finest powder compatible with a successful filtration. The black, in fact, acts only by its surface, and in proportion to that surface.

It is to be remarked that black, in grains which has been previously washed and dried, produces a more prompt filtration than when it has not been subjected to this preparation.

The Dumont filters are of different sizes; the small contain about 6 or 8 kilogrammes of black, and as much as 100 kilogrammes are required for the largest. By means of this apparatus syrups may be filtered of different degrees of density, from the most feeble to the highest, which mark 28 or 30 degrees by the areometer when cold. If operating on syrups marking 35 or 36 degrees (or from 31 to 32 boiling), it will be necessary to pour them into the filter very hot, say, at from 70 to 80 degrees Centigrade. For intermediate densities it will be sufficient that the temperature of the syrups may vary from 45 to 55 degrees. When filtering hot, we should use, as has already been said, a some-

what coarser charcoal; the operation requires a little longer time, but the product is not altogether as completely discolored.

The superiority of syrups thus filtered, in regard to agreeable flavor, over those which are boiled with the black, is indisputable, and may well be imagined. Indeed, animal black communicates to syrups heated with it, a disagreeable taste, which is more decided as the proportion of black is increased; the moistening and washing, on the other hand, deprive the bone black of a great part of its soluble principles; and, as the operation is conducted below the boiling point, and even sometimes cold, it is another reason why the syrups do not have so unpleasant a flavor as when boiled with the black.

The use of Dumont's filter, in addition to being productive of a very decided superiority, on account of perfect decolorizing and a good flavor, offers a real advantage in washing the black. In the old process it was necessary to wash the residual charcoal in many waters to remove the sugar with which it was impregnated; this required a very expensive evaporation if the waters were to be used for a second clarification. This long and troublesome work is entirely avoided by the Dumont filter. Without disturbing the apparatus, it is sufficient to pour on the black a sufficient quantity of water to remove all the sugar promptly, and what is more important we obtain, at the first flow, about three-fourths of the syrup contained in the black at very nearly the same degree of density as that from the original operation, especially if the cock is closed a little, so as to reduce the stream of syrup, and thereby retard the filtration. The rest should be put with the skimmings, or poured into a new clarification. The importance of the above operation, in an economical point of view, will be readily understood by all who manipulate sugars. It is estimated that this process has a power of decoloration equal to three times that of the old system, and the value of the decolorized syrups is increased 20 per cent.

We should remark, that in order to make a second

decoloration with the same black, or to proceed with the washing of the latter, the operation should be made before twenty-four hours have elapsed; for the prolonged delay of the sugar in contact with the animal black causes a whitish decomposition, which, when added to syrup or the water of washing, renders them very difficult to clarify.

Animal black which has been used for decolorizing sugar, may be employed advantageously as a manure. Its decolorizing property may be restored by revivification, which consists in submitting the black to calcination, which carbonizes the adhering organic substances, and uncovers the surface of the charcoal. Animal black may be revived 20 or 25 times; the loss is estimated at 4 or 5 per cent. at each revivification.

Besides its decolorizing properties, animal black possesses the quality of neutralizing the alkalies.

Saccharometer (Pese-sirop).

The saccharometer is an instrument, the object of which is to estimate the gravity of saccharine liquids. Its point of departure (or zero), placed at the top of the stem, is distilled water; it is graduated to 50 degrees; for the higher degrees it moves with great difficulty in the liquid. The reading of this areometer is the opposite of that of the alcoholometer, that is, the scale is descending; the less it sinks in a liquid, the greater the proportion of saccharine matter does it indicate.

The saccharometer is usually a glass tube blown into an elongated bulb, and loaded at the lower extremity with a lead weight; the inconvenience, inseparable from having too great a length of stem, should induce the liquorist to have several saccharometers; one comprising the densities from 0 to 20 degrees, and another from 20 to 50 degrees. It may be understood that, with an equal length of stem, the degrees may be four times greater, and the half and quarter degrees may be observed on such an instrument as readily as the whole degrees on one bearing the entire scale. Like all other areometers,

the saccharometer is more delicate in its indications, when it has a large bulb and the stem is more delicate. Heat causes a marked difference in the degrees indicated by the instrument when examining saccharine liquids; thus, a boiling syrup, which marks 31 degrees, will give 35 degrees when cold; it is therefore indispensable, whenever it is desirable, to ascertain the degree of any syrup very exactly, that its temperature should be reduced to 15 degrees Centigrade.

Liquorists are frequently guilty of the carelessness of taking hold of the saccharometer with dirty hands, of leaving the stem soiled with foreign substances, or at least wet when they have taken the trouble to wash it. Moreover, they plunge the instrument carelessly into the syrup to be weighed, so that, before attaining a state of rest, it oscillates and covers itself with the liquid to a greater or less height. All these circumstances increase the weight of the instrument, and cause false indications of the density of the syrup. To obviate these inconveniences, it is proper, before using the instrument, to wash it carefully, and dry it thoroughly.

It is best, also, to have the syrup when examined in a suitable vessel, large enough for the saccharometer to be plunged into it with ease; a glass or tin tube, having a little larger diameter than the bulbous portion of the instrument, will answer. It is important to maintain the tube in a vertical position, and so arrange it that it shall be full of liquid when the saccharometer shall have attained its point of equilibrium; then note the degree.

Frequently saccharometers are carelessly constructed, and indicate the degrees *more* or *less;* the use of such instruments may cause an error both in the value of the product and in the preparation of liqueurs. These instruments, manufactured at a low price, have not been prepared with the necessary care and according to the standard. It is known, too, that saccharometers are graduated by the aid of paper scales, fixed within the stem of the instrument by means of sealing-wax or glue. This method does not, under certain circum-

stances, afford the full guarantee which is desirable; in fact, the paper on which the scale is written becomes puckered, warped, or deranged; the instrument is then defective, and only fit to be thrown aside. The liquorist should select his saccharometer with the greatest care.

The two tables which follow will demonstrate conclusively the advantages which are derived from the use of the saccharometer. They indicate in grammes and centigrammes the quantity of sugar contained in a litre of syrup—one for *crude* or brown sugar and the other for refined sugar.

In very many circumstances, these tables will render great service. Let it be desired to know, for example, the quantity of sugar contained in 18 litres of syrup of brown sugar at 33 degrees: on consulting the first table, it is found that one litre contains 902 grammes and 22 centigrammes; multiply 902.22 by 18, and we have the product 16.239.96, which gives, by neglecting the two last figures, 16 kilogrammes and 239 grammes of sugar.

TABLE *indicating the quantity of good brown (crude or raw) Sugar contained in a litre of cold Syrup.*

At the temperature of 15° C.

Degree.	Weight.	Degree.	Weight.	Degree.	Weight.	Degree.	Weight.	Degree.	Weight.
	gr.		gr.		gr.		gr.		gr
0.5	13.67	8.5	232.39	16.5	451.11	24.5	669.83	32.5	888.55
1.0	27.34	9.0	246.06	17.0	464.78	25.0	683.50	33.0	902.22
1.5	41.01	9.5	259.73	17.5	478.45	25.5	697.17	33.5	915.89
2.0	54.68	10.0	273.40	18.0	492.12	26.0	710.84	34.0	929.56
2.5	68.35	10.5	287.07	18.5	505.79	26.5	724.51	34.5	943.23
3.0	82.02	11.0	300.74	19.0	519.46	27.0	738.18	35.0	956.90
3.5	95.69	11.5	314.41	19.5	533.13	27.5	751.85	35.5	970.57
4.0	109.36	12.0	328.08	20.0	546.80	28.0	765.52	36.0	984.24
4.5	123.03	12.5	341.75	20.5	560.47	28.5	779.19	36.5	997.91
5.0	136.70	13.0	355.42	21.0	574.14	29.0	792.86	37.0	1011.58
5.5	150.37	13.5	369.09	21.5	587.81	29.5	806.53	37.5	1025.25
6.0	164.04	14.0	382.76	22.0	601.48	30.0	820.20	38.0	1038.92
6.5	177.71	14.5	396.43	22.5	615.15	30.5	833.87	38.5	1052.59
7.0	191.38	15.0	410.10	23.0	628.82	31.0	847.54	39.0	1066.26
7.5	205.05	15.5	423.77	23.5	642.49	31.5	861.21	39.5	1079.93
8.0	218.72	16.0	437.44	24.0	656.16	32.0	874.28	40.0	1093.60

TABLE *indicating the quantity of refined Sugar contained in a litre of cold Syrup.*

At the temperature of 15° C.

Degree.	Weight.	Degree.	Weight.	Degree.	Weight.	Degree.	Weight.	Degree.	Weight.
	gr.		gr.		gr.		gr.		gr.
0.5	12.50	8.5	212.50	16.5	412.50	24.5	612.50	32.5	812.50
1.0	25.00	9.0	225.00	17.0	425.00	25.0	625.00	33.0	825.00
1.5	37.50	9.5	237.50	17.5	437.50	25.5	637.50	33.5	837.50
2.0	50.00	10.0	250.00	18.0	450.00	26.0	650.00	34.0	850.00
2.5	62.50	10.5	262.50	18.5	462.50	26.5	662.50	34.5	862.50
3.0	75.00	11.0	275.00	19.0	475.00	27.0	675.00	35.0	875.00
3.5	87.50	11.5	287.50	19.5	487.50	27.5	687.50	35.5	887.50
4.0	100.00	12.0	300.00	20.0	500.00	28.0	700.00	36.0	900.00
4.5	112.50	12.5	312.50	20.5	512.50	28.5	712.50	36.5	912.50
5.0	125.00	13.0	325.00	21.0	525.00	29.0	725.00	37.0	925.00
5.5	137.50	13.5	337.50	21.5	537.50	29.5	737.50	37.5	937.50
6.0	150.00	14.0	350.00	22.0	550.00	30.0	750.00	38.0	950.00
6.5	162.50	14.5	362.50	22.5	562.50	30.5	762.50	38.5	962.50
7.0	175.00	15.0	375.00	23.0	575.00	31.0	775.00	39.0	975.00
7.5	187.50	15.5	387.50	23.5	587.50	31.5	787.50	39 5	987.50
8.0	200.00	16.0	400.00	24.0	600.00	32.0	800.00	40.0	1000.00

CHAPTER XX.

SYRUPS.

SYRUPS are liquid compounds, resulting from the concentrated solution of sugar in plain water, or in water impregnated by emulsion, maceration, or decoction with the principles of various substances; or of a solution of sugar in the fresh or fermented juice of fruits, wine, vinegar, &c. These products are obtained in the cold way or by heat; the latter is almost the only one used.

It is not, however, sufficient to know that a syrup can be obtained by dissolving sugar by the assistance of heat in water, or some other prepared liquid; it is necessary to know, also, how to estimate the qualities of the sugar, and to vary the proportions of the substances employed, according to the character of the liquid to be converted into syrup; to be acquainted with the precautions requisite for the clarification; and to manage the

fire properly, in order that the evaporation may be accomplished rapidly and by a quick ebullition. On this account, we shall indicate under each receipt what is proper to be done.

The syrups manufactured by the liquorist are divided into two very distinct classes, simple and compound syrups; both are used for cooling beverages.

Syrups are further divided into two kinds, syrups of pure sugar, and syrups of sugar and glucose, or *glucosed syrups* (*sirops glucosés*).

Degeneration and Preservation of Syrups.

Many causes may concur to produce changes in syrups, and cause them to degenerate partially or entirely.

Among these causes fermentation occupies the foremost place; it may be set up when a syrup has not been boiled enough, or when it contains an excess of mucilaginous substances; an unsuccessful clarification also causes this change; the impure portions not having been thrown off from the syrup, decompose it in time. Syrup ferments, also, if it has been boiled too much, or concentrated to too high a degree, because the excess of sugar crystallizes; the crystals when formed gradually attract a portion of the sugar contained in the syrup, and grow at the expense of the sugar necessary for its preservation.

Fermentation may also originate if the syrup be corked before it is cold; the vapor of water which escapes from it, being condensed into a liquid, dilutes the upper stratum, this the next, and so on, thus destroying the equilibrium of the mass. The same phenomenon occurs if the vessel happens to be moist; the water, being lighter than the syrup, rises to the surface. Finally, if syrups are left in a moderately warm place, and in vessels that are not quite full, fermentation will take place still more promptly than in the preceding cases; for it is well known that air and moisture are the principal agents in every fermentation.

When fermentation commences, the syrup becomes

clouded and then frothy. Carbonic acid is formed, which traverses the liquid, and, raising a froth, very often drives out the corks with an explosion, and throws the syrup out of the vessel which contains it. The syrup, which has undergone this alteration, becomes acid, and changes color; if red, it becomes brighter; by degrees the fermentation is checked by the presence of the alcohol which is formed; but the syrup has a vinous odor, and its consistency is not so great. If the syrup which has experienced these changes contains aromatic or volatile principles, they are entirely lost; if it contains fixed acids, it is possible to restore its original properties by heating it; by means of this operation the carbonic acid and alcohol are drawn off; it is, however, more convenient to clarify it anew and evaporate it to a proper consistency.

Another species of change occurs in acid syrups when they are boiled too much, or when the substances used are too acid. A short time after they are prepared, they let fall to the bottom of the bottles a considerable deposit; and sometimes they even form a single concrete mass. By a moderate heat, they may be restored to their fluidity, and their original transparency, but they lose it again very soon. This deposit is due to a combination of the acid with the sugar. It never presents crystals; it has the appearance of cauliflower; it is looked upon as analogous to grape sugar.

Mouldiness is also an alteration which may manifest itself when the bottles of syrup are corked before they are entirely cold, or when the bottles have been damp when filled. Emptying prolonged through days may also occasion mouldiness in a well-corked vessel; this comes from the slight moisture which, after rising from the syrup, has circulated in the vacant space of the vessel, falls back on the surface of the syrup in the form of water, and does not mix with it because it is not shaken.

Syrups to be preserved should be put in well-corked bottles, always full; they must be kept in a cellar, or in a cool place.

They may also be preserved an indefinite time by depriving them of air, by boiling them in a water-bath in well-corked bottles.

Receipts for Syrups.

The following receipts for syrups are based on the same quantity of sugar and liquid; they should therefore produce results which are very nearly equal.

It is understood that the receipts may be increased or diminished at will as required, always, however, using the proportions indicated.

Simple Syrup (*Sirop de Sucre*).

Simple syrup is a liquid composed only of sugar and pure water; there are two kinds, syrup of *raw* or *crude* (brown) *sugar*, and syrup of *refined* or *white* sugar.

The first has been sufficiently noticed in the article relating to the clarification of sugar, and we may dispense with further allusion to it.

We shall only insist on the choice of sugar intended for syrup of brown sugar. It is better to employ only those that are in good condition, and free from taste and bad odors, in order to avoid having the perfume of liqueurs made from this syrup being affected by it.

The syrup of brown sugar is employed in the manufacture of common (*ordinaire*) and *demi-fines* colored liqueurs. The liquorist ought always to have a certain quantity prepared in advance; it should be boiled to 31 degrees hot and 35 degrees cold; in this condition, and by observing the precautions we have indicated above, it may be preserved for a long time.

The syrup of white sugar is prepared as follows:—

Simple Syrup.

Refined white sugar . . .	50 kilogrammes
Pure water	26 litres
Whites of eggs, number . . .	4.

Place the sugar, broken into pieces of average size, into an untinned copper pan or kettle. Add 17 litres of pure

water, and 6 litres of albuminized water (see the preparation of this water, p. 379); stir the whole with a spatula to dissolve the sugar, and proceed with the clarification, as has been said, by pushing the fire actively in order to prevent the prolonged action of the heat from coloring the syrup (this inconvenience is avoided by using steam); taking care, however, to regulate the fire so as not to throw the syrup over the edge of the pan. This accident would render the addition of water necessary, which would then have to be evaporated; this objectionable manipulation would communicate a color to the syrup which we seek to avoid. The clarification being finished, ascertain if the syrup has boiled enough by dipping the skimmer into the syrup and touching the finger to it; then apply the finger to the thumb, and see if the syrup forms a thread without breaking when they are separated; (32°) when this point is reached it is filtered through a woollen cloth or bag.

An ordinary linen towel may also be employed for straining syrups, but in this case care must be taken to moisten it with water and wring it out before using it. If this precaution is neglected, the syrup will pass with difficulty and will acquire the taste of the linen.

Syrup of white sugar is employed for the manufacture of demi-fine, fine, and superfine liqueurs; that which is intended for sale should be inclosed in bottles, the syrup being yet tepid in order to facilitate its introduction into these vessels; nevertheless the bottles must be corked only when they are entirely cold.

It should be observed that in pouring a hot syrup into a can or jar, if the syrup is allowed to become cold while uncovered, there will be formed on the surface a thin pellicle of sugar-candy, which, on decantation into the bottles, remains in a state of suspension, or falls to the bottom. This inconvenience is prevented in the following manner: a clean sponge filled with clarified water is shaken over the vessel or can which contains the syrup until the moment when the pellicle is seen to have disappeared. In the former case the transparency

of the liquid is disturbed; in the latter the formation of large crystals of sugar candy is excited.

Syrup of Orange Flowers.

Refined white sugar . . .	50 kilogrammes.
Orange-flower water (triple) .	5 litres.
Pure water	21 "
Whites of eggs, number . .	4.

Dissolve the cracked sugar in 13 litres of pure water and 6 litres of albuminized water, clarify it by the methods already described, then, after straining the syrup, add the orange-flower water, well filtered; mix quickly and cover. This syrup, which ought to weigh 31° after the mixture, should, however, weigh 36° when cold.

The syrup of *roses* is prepared in the same way.

Syrup of Capillaire.

Refined white sugar . .	50 kilogrammes.
Canada capillaire (*Maidenshair, Adiantum pedatum*) . .	2 kilogms, 500 grms.
Pure water	26 litres.
Whites of eggs, number .	4.

Infuse two-thirds of the capillaire for two hours in 18 litres of water at a boiling temperature; add the sugar to the infusion. After this has been passed through a sieve, clarify with the albuminous water; and when the syrup has been boiled to 31°, pour it into a can or other vessel on the rest of the leaves of the capillaire; allow it to infuse for two hours, and strain it through a woollen bag with two or three sheets of filtering paper reduced to a pulp.*

* As described by Dubief:—The paper is torn into shreds, steeped in a little water, well beaten in a mortar, washed in two or three waters, passed through a sieve, and pressed nearly dry; it is then returned to the mortar with a sufficient quantity of the liquid to be filtered to form a stiff paste, which is reduced to the consistency of thin gruel by gradual additions of the liquid. It is then passed through a hair sieve which is shaken to facilitate the flow; if any of

The leaves of the capillaire which have been infused in the syrup should be washed in warm water, and this poured into the bucket with the skimmings.

The syrup of capillaire is rendered more odorous by adding to the leaves, while infusing in the boiling syrup, 125 grammes of *Pekao tea;* this is preferable to employing orange-flower water, as is done by some liquorists, in this syrup.

If it happens that it is not possible to procure the genuine Canada capillaire, and it is necessary to use the capillaire of Montpellier (*Adiantum capillus veneris*), care must be taken to increase the dose of the latter one-third; that is, to use in this receipt 3 kilogrammes and 750 grammes.

Syrup of Tea.

This syrup is prepared in the same manner as the syrup of capillaire, employing only half the quantity of leaves; that is to say, 1 kilogramme and 250 grammes, viz.:—

Imperial tea	1 kilogramme.
Pekao tea	250 grammes.

Syrup of Gum Arabic.

Refined white sugar . . .	50 kilogrammes.
White gum arabic	6 "
Pure water	29 litres.
Whites of eggs, number . . .	4.

Wash the gum to remove the dust and other substances which may be attached to it, and dissolve it in 6 litres of water, stirring it frequently to hasten the solution. After the complete solution, strain through a

the paper remains on the sieve, it is returned to the mortar and the operation repeated.

By gradually adding one-fourth or one-third of the liquid to this pulp, a true size is obtained, which is then poured on the filter. As the liquid flows off, it is continually poured back on the filter until it runs clear; then the rest of the sized liquid is poured in the filter, and after it the three-fourths or two-thirds which was at first reserved. —*Trans.*

close linen cloth, and add the boiling syrup which has been clarified in the meantime; continue the boiling for a few minutes, then draw the pan from the fire and examine the syrup with the saccharometer to see if it weighs 32°. Boil to this degree, and filter, while hot, through a woollen bag lined with filtering paper (2 or 3 sheets) reduced to a pulp.

Alcohol at 90 degrees is used as a test for the presence of gum in syrup, and to approximate to its quantity. It is sufficient to pour into the liquid twice its volume of alcohol; a white flocculent precipitate falls down, which is abundant in proportion to the quantity of gum which the syrup contains, and which is quite sensible even when the proportion of gum does not exceed a hundreth part.

Syrup of Marsh Mallow (*Guimauve*) (*althea officinalis*).

Refined white sugar . . .	50 kilogrammes.
Dried root of marsh mallow, very white and crushed . . .	5 "
Pure water	29 litres.
Whites of eggs, number . .	5.

Wash the mallow roots carefully many times in tepid water, crush them with a pestle, or cut them into smooth bits, then place them on the fire in a pan with 20 litres of water, and boil for twenty minutes; strain through a sieve without pressing, add the sugar to the infusion, clarify, boil to 32 degrees, and filter as for gum syrup; add 25 centilitres of orange-flower water to render the perfume of the syrup more pleasant.

The syrup of marsh mallow is difficult of preservation, because of the large proportion of mucilage it contains.

Lemon Syrup.

Refined white sugar . . .	50 kilogrammes.
Concentrated spirit of lemons (ésprit de citron)	50 centilitres.
Citric acid	400 grammes.
Pure water	26 litres.
Whites of eggs, number . .	4.

Clarify and boil the sugar syrup alone to 32 degrees, strain through a woollen bag, then add the spirit of lemon and the citric acid, which has been previously dissolved in one litre of water and filtered; stir the mixture quickly, and bottle it as soon as it becomes tepid; cork it only when entirely cold.

Tartaric acid may, in case of necessity, replace the citric acid by doubling the quantity (800 grammes).

The process we have described is preferable to that in which the juice and rinds of the lemons are used; it is not liable to the objection of leaving mucilage in the syrup, which after a short time becomes turbid; besides the syrup of lemon, prepared by the above receipt, cannot be excelled for strength of perfume and delicacy of flavor.

Lemon syrup is liable to a species of alteration, of which we shall speak in the article on *Syrup of Gooseberries.*

Syrup of Oranges.

Refined white sugar . . .	50 kilogrammes.
Concentrated spirit of orange (ésprit d'oranges)	50 centilitres.
Tartaric acid	800 grammes.
Pure water	26 litres.
Whites of eggs, number . .	4.

Pursue the same course in every particular, as described for the preceding.

The *syrup of bitter orange peel* is prepared like the preceding, employing the same quantity of the spirit of Dutch curaçoa (*ésprit de curraçoa de Hollande*).

The syrups of *citric* and *tartaric acids* are prepared in the same way, using 500 grammes of the acid for the former, and one kilogramme of acid for the latter.

Syrup of Violets.

Refined white sugar . .	50 kilogrammes.
Fresh violets, separated from the stems and calices . .	5 kilog., 250 grams.
Pure water	26 litres.

Bruise the violets very slightly in a marble mortar; then place them in a tinned water-bath; pour on 15 litres of water at 60° Cent.; agitate for some minutes and press lightly, squeezing out the liquid; return the flowers to the water-bath, and pour on the rest of the water (11 litres) boiling. After infusing for twelve hours, pass with pressure through a clean moistened cloth which is free from odor; allow it to settle, and decant the clear liquid, which is returned to the water-bath; add the sugar and dissolve with a gentle heat, stirring it occasionally to hasten the solution; keep the vessel covered to prevent evaporation. When the sugar is completely dissolved, extinguish the fire; and after the syrup is entirely cold, filter.

Cultivated violets are preferable to the wild ones, which are less aromatic and not so highly colored; the single to the double, which have scarcely any odor; and those of early spring to those which blossom in autumn.

The use of the tinned water-bath is indispensable for procuring a syrup of violets with a good blue color. The action of the tin appears to depend on its facility of oxidation, by reason of which it saturates, as they form, the acids arising from the organic matter, and prevents their reacting on the blue color. By means of a tinned vessel we may even restore the blue color to the syrup of violets, which has become red or weakened by a slight fermentation, by heating it therein and allowing it to stand for some days in contact with the tin.

Syrup of violets, when taken from the water-bath is sometimes observed to be decolorized; but a more or less prolonged contact with the air will restore the color.

A syrup is often met with in the market prepared from an infusion of orris root, and colored by means of litmus, which is sold as syrup of violets; it may easily be recognized. From the first it is not of so clear a blue; it has a violet tint, and when the vial or flask which contains it is held between the eye and the sunlight, or the flame of a candle, it appears to be of an intense red; its taste, far from being pleasant and mucilaginous like that of the syrup of violets, is, on the

contrary, urinous and disagreeable. If a drop of an acid is added to this syrup of litmus, it instantly becomes of a very brilliant poppy red, while the syrup of violets under the influence of acids still preserves a violet tint very different from the preceding. Finally, the alkalies which change the color of syrup of violets to a brilliant green have no effect on the litmus.

The syrup of violets is often used as a reagent.

Syrup of Orgeat.

Refined white sugar . .	50 kilogrammes.
Sweet almonds . . .	3 kilogrms, 125 grms.
Bitter almonds . . .	3 " 125 "
Gum tragacanth in flakes . . .	50 "
Orange-flower water . .	60 centilitres.
Pure water.	28 litres, 50 centilitres.

Throw the almonds into a basin of boiling water, and when the skins slip off easily, cast them on a sieve and place them in cold water; skin them and put them in another vessel of cold water to prevent them from becoming yellow; then take them out in parcels with a skimmer to be ground in a wooden bowl by a cannon ball, adding some of the 28 litres of water in small quantities in order that the almonds may not be transformed into oil; turn the bowl until the almonds are very fine, which will be ascertained by putting a little of the paste in the mouth and pressing it between the teeth. If it contains no bits of almonds, the operation of grinding is finished. Now put the paste of almonds in an earthen pan, and when all the almonds have been reduced to the same state, water is added to form about half the prescribed quantity (12 or 13 litres), beating it with the skimmer, then pass through a tolerably fine hair sieve and put the paste in a linen cloth; put it under the press; then return the paste to the earthen pan and mix it with more water so as to make 26 litres of *milk of almonds*; strain this milk through a silk sieve, and pour it into a pan over the sugar. Heat it with frequent stirrings to hasten the solution of the sugar; as

soon as it is melted remove it from the fire. At this moment, add the orange-flower water and the tragacanth, which latter has been dissolved in advance in two litres of cold water from the receipt, and passed through a wet cloth; mix the whole for some minutes and pass through a fine silk sieve.

Syrup of orgeat should never be skimmed; it is necessary to stir the mixture from time to time so long as it is tepid; then pour it into bottles and keep it in a cool place.

It often happens that the syrup of orgeat, in spite of all the pains taken with it, separates into two parts a very short time after it is made; the lower portion clear and transparent, the upper white and thick. This separation is due to the oil of almonds, which is not sufficiently dissolved in the grinding, together with a certain portion of the parenchyma in a minute state of division. The gum tragacanth is used for the purpose of maintaining the equilibrium of the parts in the syrup.

The action of the fire is injurious to the syrup of orgeat, and hence it must not be boiled; the parenchyma being only in a state of minute division and not in combination, and assisted by the mucilaginous principles of the almonds, will rise to the surface and act as a clarifier.

The grinding is also very important; for if it is neglected to sprinkle the water on the almonds in sufficient quantity, they turn to oil, the emulsion is imperfectly made, and the separation takes place all the more promptly.

A mustard-mill answers admirably for the operation of grinding; it allows of the use of a greater quantity of water than can be put into the bowl, and yields a milk of almonds which is a more perfect emulsion; and finally, those who use this mill affirm that the syrup of orgeat never separates even when it contains no tragacanth.

The Syrup of Pistachios is prepared in the same manner as the syrup of orgeat, the almonds being replaced by pistachio nuts.

Currant Syrup (Sirop de Groseilles Framboisé).

Refined white sugar . . .	. 50 kilogrammes.
Conserve of red currants (1st quality)	. 26 litres.

Decant and filter the conserve; then pour it on the sugar in the kettle, heat rapidly, stirring with a wooden spatula to hasten the solution of the sugar; mash and crush it if necessary; as soon as it begins to boil, remove it from the fire and let it stand for a moment for the scum to settle. When the scum shall have acquired a little consistency, remove it carefully with the skimmer; pass through a woollen bag without filtering; the hot syrup ought to weigh 32°.

The clarification of currant syrup is effected spontaneously, but care should be taken not to move it for a few minutes before it boils, for fear of disturbing it, and thereby injuring the limpidity of the syrup.

The syrup of *Black Cherries* is prepared exactly in the same way. It may answer for coloring syrups of too light a shade.

From whim or fancy, consumers demand a very highly-colored currant syrup, so that a very small quantity poured into a glass of water produces a very high color; the conserve is powerless to produce this result, and it is necessary to use other means.

The following is a receipt for a *fancy syrup of currants* (*sirop de fantasie à la groseille framboisé*) with which the public has always been satisfied as well for color as for flavor and perfume.

Sugar	. 50 kilogrammes.
Conserve of currants . .	. 12 litres.
Dark wine of Loire . .	. 12 "
Raspberry vinegar . .	. 1 litre, 50 centilitres.
Tartaric acid . . .	150 grammes.

The wine, conserve, and vinegar are filtered together and poured on the sugar in the kettle, and the operation conducted as above. The acid, which should have been

dissolved in a half litre of water and filtered, is added only when the syrup is taken from the fire, in order to prevent the syrup, by its contact with the acid under the influence of heat, being converted into glucose.

As we have said above, the syrups of acid fruits are liable to an altogether peculiar alteration, and may form a considerable deposit or even granular mass, due to the separation of the sugar, which, when redissolved in water and concentrated anew, will be found to have lost its power of crystallizing, and presents the appearance of a granular, compact mass of grape sugar; it is merely glucose which has been formed under the influence of the acid of the fruit on the sugar. Citric and tartaric acids, which are found in currants, cherries, raspberries, and lemons, are particularly liable to produce this effect.

It will be necessary now to explain why this transformation, which is so injurious to syrups, is not always produced, and what may be the means of preventing it. We quote from M. Guibourt, who is both a man of science and a skilful workman:—

"I am far from denying the influence of heat on the transformation in question; but I attribute a much greater influence to the fermentation which may be developed in the syrup. Thus, when badly fermented juice of currants still contains pectine in solution, or when the sugar has been dissolved at too gentle a heat to destroy all tendency to fermentation in the juice, the syrup ferments, and then it almost certainly assumes the form of a granular mass. When, on the contrary, a well-clarified juice is made up with the best quality of sugar, and the syrup is heated until by the escape of carbonic acid the boiling of the syrup is clearly distinguished, it will keep well and will not solidify. I have even seen syrup of currants prepared in this way which was boiled too much, which, instead of depositing concrete grape sugar, threw down transparent crystals of cane sugar. In my opinion, therefore, this transformation of acid syrups into grape sugar is not to be attributed to excess of boiling; it is rather due to

some remains of a tendency to fermentation which it is necessary to destroy."

Syrup of Cherries (Sirop de Cerises).

Refined white sugar . . .	50 kilogrammes.
Conserve of red cherries (cerises) .	26 litres.

Decant and filter the conserve and pour it into the kettle on the sugar; heat quickly; remove from the fire as soon as it begins to boil; let it rest a few minutes; skim and pass through a blanket, or filter if necessary; this syrup should weigh 32° hot.

Very often this syrup is made during the cherry season, in order to save the trouble of preparing the conserve; in which case the operation is as follows:—

Take well-ripened cherries, express the juice and separate the seeds; allow this juice to stand twenty-four hours, then decant and filter; then finish the operation as for a syrup made with the conserve.

Syrup of Raspberries (Sirop de Framboisés).

Refined white sugar . . .	50 kilogrammes.
Conserve of raspberries . . .	26 litres.

Follow the directions given for syrup of currants.

This syrup may be made during the raspberry season by the following method, which requires less time than that by extracting the juice:—

White sugar	50 kilogrammes.
Ripe raspberries	50 "

Throw the fruit into a copper pan along with the sugar reduced to coarse powder; mix the whole together and boil, stirring all the while with a skimmer until the syrup marks 31°; strain through a bag, several times if necessary.

Syrup of Mulberries (Sirop de Mures).

Refined white sugar . . .	50 kilogrammes.
Mulberries (not perfectly ripe) .	50 "

Put them in a pan; heat and boil, stirring the mixture until the boiling syrup marks 31°; then strain through a blanket, leaving the marc above to drain; do not filter.

The syrup of mulberries is usually employed in gargles for affections of the throat.

The marc or residuum of mulberries, raspberries, and other fruits which contain syrup, ought to be well washed and thrown into the infusion of black currants. The washings should be put into the bucket with the skimmings.

Syrup of Raspberry Vinegar.

Refined white sugar . . .	50 kilogrammes.
Raspberry vinegar	12 litres.
Conserve of black cherries . .	4 "
Pure water	10 "

Dissolve the sugar in the conserve of cherries and water mixed; when the syrup is boiling, remove it from the fire and let it stand a moment; skim, and add the raspberry vinegar; stir the mixture well, and strain through a blanket, or filter if necessary.

Syrup of Brandy Punch (*Sirop de Punch au Cognac*).

Brown sugar of good quality . .	50 kilogrammes.
Cognac brandy at 58° . . .	30 litres.
Concentrated spirit of lemon . .	10 centilitres.
Citric acid	60 grammes.

Clarify the brown sugar and concentrate to 32° boiling; strain and filter; put the syrup into a can; then add the cognac, spirit of lemon, and the acid; the last being dissolved in a little water; mix quickly; cover and lute the joints of the cover with paper bands to prevent the evaporation of the spirituous portion; rummage up well after it is perfectly cold.

By replacing the cognac brandy by *reduced troix-six* (dilute spirits of wine) of the same degree, we shall have *sirop de punch ordinaire.*

Syrup of Cherry Punch (Sirop de Punch au Kirsch).

Refined white sugar . . .	. 50 kilogrammes.
Kirsch (cherry brandy) at 55°	. 25 litres.
Spirits of wine at 85° . . .	. 4 "
Spirits of nuts (*ésprit de noyaux*)	. 1 litre.
Concentrated spirits of lemon	. 10 centilitres.
Citric acid	. 60 grammes.

Proceed as with the last.

Common Syrup of Rum Punch (Sirop Ordinaire de Punch au Rhum).

Brown sugar of good quality .	. 50 kilogrammes.
Common rum at 55° . . .	. 20 litres.
Spirits of wine at 85° . . .	. 7 "
Concentrated syrup of lemons	. 10 centilitres.
Citric acid	. 60 grammes.

This is prepared in the same way as the syrup of brandy punch.

Fine Syrup of Rum Punch (Sirop Fin de Punch au Rhum).

Refined white sugar . . .	. 50 kilogrammes.
Fine rum	. 20 litres.
Spirits of wine at 85° . . .	. 10 "
Concentrated spirit of lemon	. 10 centilitres.
Citric acid	. 60 grammes.
Hyson tea	. 250 "

Make a strong decoction of the tea with four litres of boiling water, and add it to the syrup concentrated to 36 degrees boiling; the rest of the operation is like that for syrup of brandy punch.

Remark.—There is no necessity for burning the punch made from any one of the four receipts, in order to serve it to consumers. To make a delicious punch, it is only necessary to add two parts of boiling water to one of syrup.

Glucosed Syrups (Sirops Glucoses).

Glucosed syrups are mixtures of pure sugar with glucose in variable proportions, according to the taste of the liquorist. They are now extensively sold in the market; indeed, it may be said that three-fourths of the syrups sold for refreshments are glucosed syrups.

The preference of the public is divided principally between the syrup of currants and orgeat; although other syrups can be glucosed, yet these make up almost the entire consumption.

For this reason, we shall confine ourselves to giving the receipts for these two syrups.

Nevertheless, if it is desired to *glucose* any other syrup, it will be necessary to employ the quantity of syrup of starch indicated in one or other of these receipts.

Syrup of Currants (Sirop de Groseilles Framboisé).

Refined white sugar . . .	40 kilogrammes.
Syrup of potato starch, at 36° .	15 litres.
Conserve of red currants (second quality)	10 "
Dark wine of Loire . . .	9 "
Raspberry vinegar . . .	1 litre, 50 centilitres.
Tartaric acid	150 grammes.

Put the syrup of starch with the other liquids in the pan on the sugar, and conduct the operation as for the syrup of currants made from pure sugar.

Glucosed Syrup of Currants (Sirop de Groseilles Glucosé).
(Product 52 litres.)

White sugar	33 kilogrammes.
Tartaric acid	100 grammes.
Conserve of red currants .	9 litres.
Wine of Loire . . .	9 "
Raspberry vinegar . . .	1 litre, 50 centilitres.
Syrup of dextrine, at 36° .	15 litres.

Glucosed Syrup of Orgeat (No. 1).

Best refined white sugar . .	40 kilogrammes.
Syrup of very white starch, at 36°	15 litres.
Sweet almonds	3 kilogrammes.
Bitter almonds	3 "
Gum tragacanth	30 grammes.
Orange-flower water . . .	50 centilitres.
Pure water	21 litres.

The operation is the same as for orgeat syrup made with pure sugar.

Glucosed Syrup of Orgeat (No. 2).
(100 litres.)

White sugar . . .	60 kilogrammes.
Glucose, at 40° . . .	20 litres.
Pure water . . .	40 "
Sweet and bitter almonds .	6 kilog., 500 grammes.
Gum tragacanth . .	45 grammes.
Orange-flower water . .	75 centilitres.

(This ought to cost 115 francs per 100 litres.)

Attempts have been made to imitate syrup of orgeat in different ways, some with pumpkin-seeds, others with milk, &c.; but none of these preparations have the flavor of orgeat, nor can they be kept.

We have, however, compounded a syrup of orgeat from the tincture of benzoin and volatile oil of bitter almonds, which was a perfect imitation of the true syrup of orgeat made from almonds. We may state that our compound, submitted to the taste of a *limonadier* in Paris, of high reputation, who did not know of its being an imitation, was actually preferred to the genuine syrup. This syrup, it is true, costs as high as the other, but it obviates a great deal of labor, and dispenses with the almonds.

The following, among others, is a ready test for the presence of glucose, derived from starch in syrups:—

Place 8 or 10 grammes of the suspected syrup in a white glass bulb, add 10 grammes of a solution of caustic potash (caustic potash, 50 centigrammes; water, 45

grammes), then heat the bulb over a spirit lamp; if the syrup contains glucose, it will acquire by boiling a brownish color approaching that of coffee, and will exhale the odor of caramel; if, on the contrary, it contains no glucose, it will assume a beautiful golden yellow color.

This method, which may be adopted for testing syrups of gum, mallow, capillaire, and orgeat, will not answer for acid syrups, not even the whitest, for the sugar, being *inverted* by the acid, is also colored by the potash.

There is another test which is considered better for examining syrups containing glucose, which is as follows:—

Dissolve, in 400 grammes of water, 40 grammes of crystallized carbonate of soda, 50 grammes bitartrate of potash, and 40 grammes of caustic potash, and dissolve in 100 grammes of water 30 grammes of sulphate of copper; then mix the two solutions and filter.

If a certain quantity of this solution be introduced into a test-tube, along with a syrup prepared from crystallizable sugar, there will not be any change of color, either cold or hot; but, if there is any glucose or uncrystallizable sugar present, a deposit of protoxide of copper will be produced. However, it must be observed that syrups, which have been boiled for a long time, present the same reaction on account of the uncrystallizable sugar resulting from the prolonged action of heat on the crystallizable sugar.

CHAPTER XXI.

COLORING.

The various colors which have been given to liqueurs have been invented only with the view of gratifying the fancy of the public, which is ever seeking after novelties; in no case do they improve the liqueurs to which they may be added, and most generally they change or destroy the delicacy of the perfume.

Nevertheless, since it is customary to color certain liqueurs, it is necessary to endeavor to improve these colors as much as possible, in order that they may be healthy and pleasant.

A Fine Red Coloring.

Cochineal in powder	125 grammes.
Alum in powder	30 "
Bitartrate of potash (cream of tartar) .	30 "
Water	2 litres.

Boil the water, and throw the cochineal into it; after boiling for a few minutes, add the alum and cream of tartar and stir with a small spatula, remove it from the fire and permit it to cool, and put the whole into a stone jar, with one litre of spirit at 85 degrees to keep it.

The alum fixes the color, and the cream of tartar intensifies the brilliancy of the red.

This coloring is used for *fine* and *superfine* liqueurs; it produces all tints, from the rose to deep red, according to the quantity employed.

Common Red Coloring (*No.* 1).

Cudbear in powder	2 kilogrammes.
Alcohol, at 85°	5 litres.

Place the whole in a stone jar and stir occasionally; after digesting four days, draw off the clear liquid and filter before using, if necessary. The cudbear may be charged with a second dose of alcohol (the same quantity), and allowed to infuse until the whole of the coloring matter is exhausted.

Common Red Coloring (*No.* 2).

Archil in paste	2 kilogrammes.
Alcohol, at 85°	5 litres.

Prepare as the last.

This coloring produces a crimson or violet tint, which may be easily changed or brought to a red by the addition of caramel.

Yellow Coloring.

Saffron	125 grammes.
Water	2 litres.

Boil one litre of water, and pour it on the saffron, in a vessel which can be tightly closed; after it cools, strain and express; boil the second litre of water, and pour it on the marc of saffron; when this is cold, strain and press; put the two liquids together, and add one litre of alcohol, at 85 degrees, to preserve the coloring. In order to exhaust the saffron entirely of its coloring matter, pour one litre of alcohol at 85 degrees over it, and, after straining it off, put it aside for absinthes.

This coloring is employed in liqueurs to which the flavor of saffron is not obnoxious, but it is not adapted for all those that are colored yellow. To procure a yellow coloring without flavor, place the quantity of saffron indicated above in a hair sieve, and, after having carefully spread it out evenly, place the sieve in a small pan with double the quantity of water, that is to say, four litres; heat it until the water boils, and this will drive off the principle which causes the acrid taste of the saffron. Add a sufficient quantity of alcohol to keep it.

Caramel.

Good molasses	12 litres.
Water	5 litres.
Virgin wax	10 grammes.

Place the molasses in a deep pan and heat strongly, stir continually with a large wooden spatula, in order to prevent the molasses from attaching itself to the bottom of the pan, then, when it has arrived at the point of *caramelization*, which is recognized by the odor and the slight adhesion of the liquid to the spatula, remove the pan quickly from the fire and place it on the floor; then, little by little, pour in the water, which should be heated to 60 or 80 degrees, with caution, stirring all the time with a spatula. Finally, when this operation is finished, pass the caramel at once through a hair sieve.

The molasses when heated swells up and forms great bubbles, which would run over the top of the pan and furnace, if pains were not taken to throw into it the quantity of virgin wax indicated.

Caramel may also be prepared from brown sugar, or any other, but it will cost a great deal more, without being any better in quality. The best quality of molasses should have the preference.

Caramel will produce any shade of yellow desired, from the brightest to the most decided; it is used mainly for coloring brandies; its value for this purpose is very great. One litre of well-prepared caramel is sufficient to communicate an appropriate yellow color to brandy, to 1000 or 1200 litres of reduced trois-six.

Yellow Coloring (*No.* 2).

Certain liquorists employ for their yellow coloring an alcoholic infusion of turmeric (*curcuma*). In addition to this substance not possessing coloring properties of a high order, its peculiar action on the system should cause it to be rejected by the liquorist who is desirous of selling only good products.

Blue Coloring.

Indigo, in very fine powder . .	30 grammes.
Sulphuric acid, at 66°	300 "

Dissolve the indigo in the sulphuric acid in a stone jug or jar without corking it; shake until effervescence ceases; the product is *liquid blue* or *Saxony blue.*

In this form the blue cannot be used; it will deposit in the liqueurs, and communicate an unpleasant odor to them; the acid which is contained in it must be neutralized in the following manner:—

Place the blue liquid in an unglazed earthen pot, of the capacity of about ten litres, add two litres of water, and then sprinkle the liquid with 300 grammes of pulverized white chalk, or 500 grammes of Spanish whiting (carbonate of lime), and stir with a stick. When the

effervescence shall have ceased, let it rest, decant it, and then filter.

This color is preserved by the addition of 25 centilitres of alcohol at 85°.

Blue Coloring, No 2.

After preparing the liquid blue as described in the preceding receipt, put it in a kettle and add 8 litres of water; boil in it for a quarter of an hour a piece of white and new porous cloth, which will take up the coloring matter; then wash the cloth in many waters to remove the acid, and boil it again in 6 litres of water rendered alkaline by the addition of 5 grammes of carbonate of potash (salts of tartar). The blue coloring will leave the cloth and be disseminated in the boiling water. Filter when cold, and rinse the cloth well, that it may be used in other operations.

This coloring is to be preserved in a glass or stone vessel by the addition of 75 centilitres of alcohol at 85°.

This blue should be preferred to the preceding, because it certainly will not deposit in liqueurs, and will not vary in tint.

Blue Coloring, No. 3 (*Dissolved in Water*).

Prussian blue	60 grammes.
Oxalic acid	4 "

Reduce the Prussian blue to a fine powder, then place it in a vessel along with the acid; add the water in small quantities, after the solution is complete, filter and add 50 centilitres of alcohol to preserve it.

This blue may be distinguished from the indigo blue by being less brilliant.

Coloring for Curaçoa (*demifin*).

Brasiletto wood*	2 kilogrammes.
Brazil wood	2 "
Cream of tartar	60 grammes.
Alcohol of good flavor at 85°	10 litres.

* Brasiletto is the *Cæsalpenia Brasiliensis* and *C. crista*, and is very similar to *Nicaragua wood*. *Brazil wood* or *Hernambuco wood* is the wood of the *Cæsalpinia echinata.*

Pack the woods in a jar in alternate layers and sprinkle them with the cream of tartar; add the alcohol, and let the mixture stand eight days or more. Recharge the woods with fresh alcohol until the color is completely exhausted. This alcohol, when drawn off, may be used for a second infusion for the same coloring.

Coloring for Curaçoa (surfin).

Pernambuco wood (best quality)	4 kilogrammes.
Cream of tartar	60 grammes.
Esprit de Curaçoa surfin	10 litres.

Proceed as for the last.

Another very beautiful coloring for curaçoa is obtained by the following process:—

Pernambuco wood	2 kilogrammes.
Common water	16 litres.
Carbonate of potash	6 grammes.
Pulverized alum	90 "
Cream of tartar	60 "

Boil the water and the carbonate of potash in a copper kettle; add the Pernambuco wood and continue the boiling until the quantity of water is reduced one-half; remove it from the fire and then add the cream of tartar and the alum, and strain through a hair sieve.

The carbonate of potash facilitates the extraction of the coloring matter from the Pernambuco wood, but it causes it to pass to a reddish violet. The cream of tartar corrects this color and restores it to a decided red; the alum fixes the color.

Another substance, hæmatoxylin, which is but little known among liquorists, may be used for coloring curaçoas.

Hæmatoxylin.

Hæmatoxylin is the coloring principle of logwood (*Hæmatoxylon Campechianum*); it was discovered by Chevreul.

In a pure state, hæmatoxylin presents itself in small

rose-colored crystallized scales; its taste is sweetish, astringent, and slightly bitter. Boiling water dissolves it readily with an orange-red color; but it is much less soluble in water than in alcohol.

Acetic and tartaric acids change the color of hæmatoxylin to a brilliant yellow. Soda and potash cause it to change to a reddish purple; by the addition of larger quantities of these alkalies it becomes a violet blue, then a dark red, and finally a brownish yellow. Lime and baryta produce the same effects.

A very suitable color is produced by the following receipt:—

Hæmatoxylin in powder . . .	100 grammes.
Alcohol at 85°	2 litres.

Digest for two or three days, shaking occasionally.

If it is necessary to produce the color at once, heat the infusion in a water-bath, or use boiling water instead of alcohol.

One hundred grammes of hæmatoxylin will color one hundred litres of curaçoa.

The color of the Brasiletto and Pernambuco woods, as well as that of hæmatoxylin, is red; to change this to a golden yellow or amber, it will be sufficient to add a few drops of one of the acids of which we have spoken; but care must be taken not to put in too much acid, lest the color become a pale yellow; the curaçoa in this case, when put into a glass with water, will no longer have a rose tint. This inconvenience may, however, be corrected by carefully adding to the liquid a few drops of a solution of soda or potash.

Green Coloring.

Green coloring is produced by mixing the yellow of saffron or caramel with the blue; with the former, the *apple* and *grass green* tints are prepared; the latter produces the *olive green* or *dead leaf* shades.

The leaves of balm, veronica, and nettles are used in combination or separately by some liquorists for color-

ing absinthes (*ordinaire, demifines*, and *fines*). But in order that the absinthes may neither change nor deposit the color, it is necessary that they should weigh at least 60° or 65° Cent., the chlorophyl, which is the coloring principle of leaves, not being soluble in alcohol of a less degree of strength. This proximate principle of plants cannot in any event be used for coloring liqueurs. The expressed juices of various plants from which chlorophyl is extracted, such as meadow-sweet, smallage, and spinach, may also be used for coloring absinthes; but these colors are objectionable because they are destroyed by light.

We have indicated in the article on *Swiss absinthe* the method of preparing the green coloring for that drink.

Violet Coloring.

This is prepared by mixing the red and blue coloring in proper proportions, or according to the wish of the operator.

CHAPTER XXII.

PERFUMED SPIRITS.

The name *perfumed spirits* or *essences* is applied to alcohol charged more or less with the odorous or volatile principles of one or more substances by means of distillation. When only one article is used it is called a *simple* spirit, when several are employed it is a *compound* spirit. In pharmacy the alcoholates (*alcoolats*) are only perfumed spirits.

The constituents of perfumed spirits are alcohol, flowers, fruits, then seeds, roots, woods, and plants, or parts of plants, these last either dried or fresh.

Alcohol, being the base or solvent in the preparation of all perfumed spirits, would be a proper subject for con-

sideration in this chapter were it not treated more at length in the preceding portions of this work.

The rules which are to be followed in preparing and distilling perfumed spirits, whether simple or compound, are the same.

1. Use very pure alcohol at 85°, free from all odor of marc, empyreuma or other; the *trois-six* of the South of France should be preferred.

2. Select with judgment and skill the substances which are to be treated with the alcohol.

3. Divide, crush, or bruise these substances in order to facilitate the extraction of the volatile or aromatic principle.

4. Digest the materials in the alcohol for twenty-four hours before distilling.

5. When the mixture is put into the still, add a sufficient quantity of water, about half the quantity of the alcohol (25 litres of water to 50 litres of spirits at 85°).

6. Distill over a naked fire, in a water-bath or by steam, in suitable and well-cleaned stills.

7. Pay particular attention to the management of the fire or steam for fear of explosions and *starts*, and to avoid communicating an empyreumatic flavor to the distilled liquid.

8. Renew the water about the coil as frequently as possible, so that it may be always cool.

9. Collect in the receiver only the quantity indicated in each receipt, being careful to set aside the phlegm.

We should remark that in certain perfumed spirits a very highly concentrated alcohol will have the inconvenience, when distilling by the ordinary heat, of passing over without being sensibly charged with the volatile oil of the substance treated. It is then necessary to add water in variable quantity, according to the difficulty of distilling the volatile oil with which it is desired to impregnate the alcohol.

Perfumed spirits have less odor than aromatic waters distilled from the same substances. This is due to the fact that the volatile oils being in solution, we might say in intimate combination in the alcohol, even when in

large proportion, lose a part of their odor while they retain it in the water which only holds them in a state of suspension. Thus, if a small quantity of a perfumed spirit is poured into a glass of water, the odor will be at once developed, and if the proportion of the essence is sufficiently great, the water will become opalescent and even milky.

This effect is due to the well known fact that the more thoroughly a substance is divided, the greater is its tendency to be vaporized. It is in this way that rose-water diluted with common water becomes more odorous.

By age, perfumed spirits improve in quality, in consequence of the closer bond of union which takes place between the constituent principles: the acridity and sharpness which are always present for a while after the distillation, disappear with time. Perfumed spirits may, however, be improved at once, by exposing them, in bottles or vessels of medium size, to the influence of cold produced by a mixture of broken ice and salt. In less than six hours they will have acquired the desired fragrance and mellowness.

Perfumed spirits are kept in well-stopped vessels in some place which has the ordinary temperature.

Simple or compound perfumed spirits are used for the manufacture of all kinds of liqueurs. The liquorist should always have a certain quantity prepared in advance, so as to be able to use those only which have been standing for many months.

Rectification of Perfumed Spirits.

Generally it is all-important that perfumed spirits should be rectified, if it is desired that the product shall be of good quality.

This operation, which has been sufficiently described heretofore, should be conducted carefully and with intelligence.

Let us suppose that it is desired to rectify 52 litres of a perfumed spirit; 25 litres of common water should be added to the quantity, then distill in a water-bath until

50 litres of perfumed spirit are drawn off; the remaining two litres should be drawn off afterwards, and be set aside with the *backings* or *phlegm*. If, on the contrary, the same quantity of spirit is drawn off during the rectification as was put into the still, it will be exactly similar to what it was before, and all the advantages of the rectification will be lost.

Backings or Phlegm.

The last products of the distillation and rectification of perfumed or other spirits are called *backings* or *phlegm*.

These products are watery and acrid; they contain much essence and very little alcohol; their odor is penetrating, persistent, and empyreumatic. Nevertheless, the distillation or rectification should be pushed far enough to draw off all the alcohol which may remain in the still after extracting the perfumed spirit.

Although the phlegm may be charged with a very considerable quantity of volatile oil, it should not be employed in a distillation or rectification of perfumed spirit to which it would communicate its empyreumatic odor; it should be collected together in a barrel and distilled; the product might be employed in the manufacture of common absinthe.

Receipts for Perfumed Spirits.

The method of distilling perfumed spirits being always the same, with a few exceptions which will be pointed out, we shall not repeat the directions with each receipt.

*Essence of Orange Flowers (Esprits de Fleurs d'Oranger).**

Fresh orange flowers separated from the calices . . .	12 kilog., 500 grms.
Alcohol, 85°	52 litres.

* [NOTE.—The English and French titles are both given as a matter of interest to those who do not care to hunt up translations for the labels of all the essences, liqueurs, &c., which are offered to the public.—*Trans.*]

Digest the flowers in the alcohol in a water-bath for twenty-four hours, add 25 litres of water at the moment of distilling, lute all the joints, and proceed to draw off 51 litres of a good article; continue the operation to draw off the phlegm which should be collected, until nothing but water flows from the apparatus (which is ascertained by an alcoholometer marking *zero*), then rectify the first product, adding 25 litres of water, and draw off 50 litres of perfumed spirit.

Essence of Roses (*Esprit de Roses*).

Fresh roses (the petals) . .	25 kilogrammes.
Alcohol, 85°	52 litres.

Distill and rectify in a water-bath, to draw off 50 litres of essence. The process is conducted as above.

Essence of Violets (*Esprit d' Oeillets*).

Fresh violets, plucked from the calices,	12 kilog., 500 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Absinthe (*officinal*) [*Esprit d'Absinthe*] (*grande*).

Dried leaves and tops of wormwood (*grande absinthe*) (*artemisia absinthium*)	12 kilog., 500 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Absinthe (*Roman*) [*Esprit d'Absinthe*] (*petite*).

Dried leaves and tops of the Roman (*lesser absinthe*) (*artemisia pontica*)	12 kilog., 500 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Genipi (Esprit de Génépi).

Dried leaves and tops of Alpine genipi (*artemisia rupestris*) . .	6 kilog., 250 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Hyssop (Esprit d'Hysope).

Dried flowering tops of hyssop (*hyssopus officinalis*) . .	12 kilog., 500 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Lavender (Esprit de Lavande).

Dried lavender in flower (*lavendula angustifolia*) . .	6 kilog., 250 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Balm (Esprit de Melisse).

Balm, dried and picked (*melissa officinalis*)	12 kilog., 500 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Peppermint (Esprit de Menthe).

Dried peppermint in flower (*mentha piperita*) . . .	12 kilog., 500 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Angelica Seed (Esprit d'Angelique [semences]).

Seeds of angelica (*angelica sativa*)	6 kilog., 250 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Dill (Esprit d'Aneth).

Seeds of dill (*anethum graveolens*) 6 kilog., 250 grms.
Alcohol, 85° . . . . 52 litres.
Product, 50 litres.

Process as above.

Essence of Aniseed (Esprit d'Anis).

Aniseed (*pimpinella anisum*) . 6 kilog., 250 grms.
Alcohol, 85° . . . . 52 litres.
Product, 50 litres.

Process as above.

Essence of Star Anise (Esprit de Badiane).

Seed of star anise (*anisum stellatum*) . 6 kilog., 250 grms.
Alcohol, 85° . . . . . 52 litres.
Product, 50 litres.

Process as above.

Essence of Caraway (Esprit de Carvi).

Caraway seeds (*carum carvi*) . 6 kilog., 250 grms.
Alcohol, 85° . . . . 52 litres.
Product, 50 litres.

Process as above.

Essence of Coriander (Esprit de Coriandre).

Coriander seeds (*coriandrum sativum*) . 12 kilog., 500 grms.
Alcohol, 85° . . . . . 52 litres.
Product, 50 litres.

Process as above.

Essence of Cumin Seeds (Esprit de Cumin).

Cumin seeds (*cuminum cyminum*) . 6 kilog., 250 grms.
Alcohol, 85° . . . . . 52 litres.
Product, 50 litres.

Process as above.

Essence of Candy Carrot (Esprit de Daucus).

Seeds of candy carrot (*athamanta cretensis*)	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Fennel (Esprit de Fenouil).

Fennel seeds (*anethum fœniculum*)	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Raspberries (Esprit de Framboises),

Fresh raspberries, freed from stems (*rubus idæus*)	25 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Angelica Root (Esprit d'Angelique) (Racines).

Angelica root, dried and bruised	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Calamus.

Calamus roots (*calamus aromaticus*) .	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Ginger (Esprit de Gingembre).

Ginger (roots)	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Cascarilla.

Cascarilla bark	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Rosewood (Esprit de Bois de Rhodes).

Roots of rosewood	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Sandal wood (Esprit de Santal).

Sandal wood (*santalum myrtifolium*)	3 kilog.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Aloes (Esprit d'Aloes).

Socotrine aloes	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Catechu (Esprit de Cachou).

Catechu	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Benzoin (Esprit de Benjoin).

Gum benzoin in tears, powdered	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Myrrh.

Pulverized myrrh	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Tolu.

Pulverized balsam of tolu . .	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Muskmallow (Esprit d'Ambrette).

Seeds of muskmallow (*hibiscus abelmoschus*)	6 kilog., 250 grms.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Grains of Paradise (Esprit de Grand Cardamome).

Grains of paradise (*amomum grana paradisi*)	3 kilogrammes.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Cardamom (Esprit de Petit Cardamome).

Cardamom seeds (*amomum cardamomum*) .	3 kilog.
Alcohol, 85°	52 litres.
Product, 50 litres.	

Process as above.

Essence of Ceylon Cinnamon (Esprit de Cannelle de Ceylan).

Powdered Ceylon cinnamon .	1 kilog., 500 grms.
Alcohol, 85°	52 litres.

Digest the cinnamon with the alcohol for twenty-four hours in the still; add 25 litres of water at the time of distilling, lute

all the joints and distill over the *naked fire.* Draw off and unite the perfumed spirit and phlegm resulting from this operation; then rectify the whole over a *naked fire*, after adding 25 litres of water, and draw off 50 litres.

Essence of Cassia (Esprit de Canelle de Chine).

Pulverized cassia (*laurus cassia*)	3 kilogrammes.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process same as the preceding.

Essence of Cloves (Esprit de Girole).

Bruised cloves	3 kilogrammes.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Mace (Esprit de Macis).

Bruised mace	3 kilogrammes.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Nutmegs (Esprit de Muscades).

Nutmegs, crushed	3 litres.
Alcohol, 85°	52 "

Product, 50 litres.

Process as above.

Essence of Sassafras (Esprit de Sassafras).

Sassafras wood, in chips	3 kilogrammes.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Bitter Almonds (Esprit d'Amandes Amères).

Bitter almonds	12 kilog., 500 grms.
Alcohol, 85°	52 litres.

Product, 50 litres.

Process as above.

Essence of Apricot Seeds (*Esprit de Noyaux d'Abricots*).

Kernels of the seeds of the apricot	. 12 kilog., 500 grms.
Alcohol, 85° . . .	. 52 litres.
Product, 50 litres.	

Process as above.

Essence of Celery (*Esprit de Céleri*).

Celery seed . . .	. 6 kilog., 250 grms.
Alcohol, 85° . . .	. 52 litres.
Product, 50 litres.	

Process as above.

Essence of Cedrat (*Esprit de Cedrat*).

The rinds of fresh citrons, number .	. 300.
Alcohol, 85°	. 60 litres.

Digest the rinds with the alcohol in a water-bath for twenty-four hours. At the time of distilling add 25 litres of water, lute the still and draw off 55 litres of spirit, add 25 litres of water to the product and rectify, drawing off 50 litres of perfumed spirit.

The last product of each operation, that is to say, the ten litres left over in the distillation and rectification, should be set aside to be used in a new operation; the flavor not being sufficiently pure, nor the perfume strong enough, to justify its use in the preparation of liqueurs.

Essence of Lemon (*Esprit de Citron*).

The rinds of 400 fresh lemons.	
Alcohol, 85°	. 60 litres.
Product, 50 litres.	

Process same as preceding.

Essence of Orange (*Esprit d'Oranger*).

The rinds of 500 fresh oranges.	
Alcohol, 85°	. 60 litres.
Product, 50 litres.	

Process as above.

Concentrated Essence of Lemon.

The rinds of 800 fresh lemons.
Alcohol, 85° . . . . . . 60 litres.
Product, 50 litres.

Process as above; this essence is used to aromatize lemon syrup.

Concentrated Essence of Oranges.

The rinds of 1000 fresh oranges.
Alcohol, 85° . . . . . . 60 litres.
Product, 50 litres.

Process as above; this essence is used to aromatize syrup of oranges.

Esprit d'Anisette Ordinaire.

Anise seed	3 kilogrammes.
Star anise seed (*badiane*) . . .	3 "
Coriander "	1 kilogramme.
Fennel	1 "
Alcohol, 85°	52 litres.

Bruise the seeds in a mortar, and digest them with the alcohol for twenty-four hours; add 25 litres of water, and distill off 51 litres of the first product; then add 25 litres of water and rectify, drawing off 50 litres of perfumed spirit.

This spirit is used for *anisette ordinaire, double,* and *demi-fine.*

Esprit d'Anisette de Bordeaux.

Star anise seed	2 kilogrammes.
Anise seed	500 grammes.
Coriander seed	500 "
Sassafras wood	500 "
Muskmallow (ambrette) . .	125 "
Imperial tea	125 "
Alcohol, 85°	52 litres.

Bruise the seeds, cut the sassafras in chips, distill and rectify, as in the preceding receipt.

Product, 50 litres of perfumed spirit.

Esprit de Curaçoa Ordinaire.

Dried rinds of Seville oranges (bitter)	7 kilog., 500 grms.
Dried rinds of sweet oranges .	2 " 750 "
Alcohol, 85°	60 litres.

Steep the orange rinds in cold water, when they are sufficiently softened remove the soft inner portion of the rind as worthless, throw the outer portions into the alcohol, and, after digesting twenty-four hours, distill and rectify according to the directions given for essence of lemon, drawing off 50 litres.

When the *ribbons* or *strips* of orange peel are used, the proportions are as follows :—

Strips of Seville orange peel .	5 kilogrammes.
Strips of sweet orange peel .	1 kilog., 665 grms.
Alcohol, 85°	60 litres.

Product, 50 litres of perfumed essence.

Esprit de Curaçoa de Hollande.

Rinds of the Curaçoa orange . .	10 kilogrammes.
Alcohol, 85°	75 litres.

Draw off 50 litres as above, setting aside the 25 litres of phlegm for a new operation.

Essence of Coffee (*Esprit de Moka*).

Laguayra coffee	3 kilogrammes.
Mocha coffee	3 "
Alcohol, 85°	52 litres.

Roast the coffee slightly, reduce it to a coarse powder, digest, distill, and rectify, as for the preceding.

Product, 50 litres.

Essence of Tea (*Esprit de Thé*).

Imperial tea	2 kilogrammes.
Pekao tea*	1 kilogramme.
Hyson tea	1 "
Alcohol, 85°	52 litres.

Digest the tea for two hours in twelve litres of boiling water, then add the alcohol, digest, distill, and rectify, as directed above.

Product, 50 litres of perfumed spirit.

* *Pekao*, or *Peckoe*, is the name applied to a highly flavored tea which is used for flavoring other teas.

The essence of coffee and the essence of tea should be distilled very slowly, and, if necessary, returned upon the solid matters, and redistilled or cohobated.

CHAPTER XXIII.

AROMATIC TINCTURES.

AROMATIC tinctures are prepared by saturating spirits with odorous principles without the use of the still, by digestion or maceration, with or without the aid of heat.

We should employ for their preparation well-dried substances, as well as alcohol (85°) free from flavor. The vessels in which tinctures are prepared should be hermetically closed.

Tincture of Ambergris (*Tincture d'Ambre*).

Ambergris	32 grammes.
Alcohol, 85°	2 litres.

Digest fifteen days with a gentle heat (25 or 30 degrees), shaking occasionally, filter, and keep it for use.

Tincture of Benzoin.

Benzoin in tears (powdered) . .	250 grammes.
Alcohol, 85°	2 litres.

As above.

Tincture of Catechu (*Tincture de Cachou*).

Catechu (*terra japonica*) . . .	250 grammes.
Alcohol, 85°	2 litres.

As above.

Tincture of Musk.

Tonquin musk	15 grammes.
Alcohol, 85°	2 litres.

As above.

Tincture of Storax.

Pulverized storax (*styrax calamita*) .	250 grammes.
Alcohol, 85°	2 litres.

As above.

Tincture of Tolu.

Powdered balsam of tolu . .	250 grammes.
Alcohol, 85°	2 litres.

As above.

*Tincture of Orrisroot (Infusion d'Iris).**

Florentine orris in powder .	1 kilog., 250 grms.
Alcohol, 85°	10 litres.

Digest for at least fifteen days, shaking occasionally, and filter.

Tincture of Vanilla (Infusion de Vanille).

Vanilla beans cut into small pieces .	150 grammes.
Alcohol, 85°	10 litres.

Process same as the last.

To prepare tincture of vanilla for immediate use, the following process may be adopted :—

Vanilla cut in small pieces . .	80 grammes.
Alcohol, 85°	5 litres.
Sugar	500 grammes.

Triturate the vanilla with the sugar in a mortar, adding the alcohol gradually after the two ingredients are pretty well incorporated. When the whole is mixed, place them in a water-bath for two hours, either in a tinned copper vessel, or a stone jar, without allowing the water to boil. When cold, decant and filter.

Tincture of Curaçoa (Infusion de Curaçoa).

Rinds of the bitter orange of Curaçoa .	5 kilogs.
Alcohol, 85°	10 litres.

Bruise the orange peel without removing the inner portion,

* The author applies the term *tinctures* to those preparations in which heat is an adjuvant, while those which are prepared by maceration, at the ordinary temperature, he calls *infusions*. The distinction cannot be made in English without creating confusion.—*Trans.*

digest them in the alcohol for eight or ten days, then draw off the clear liquid and filter.

The orange peel may be treated with fresh alcohol or distilled with the proper quantity for preparing *ésprit de curaçoa ordinaire.*

Tincture of the Hulls of Bitter Almonds (Infusion de Coques d'Amandes Amères).

Hulls of bitter almonds . .	10 kilogrammes.
Alcohol, 85°	20 litres.

Digest for two months before using.

Tincture of Smaller Absinthe.

Dried leaves of the small absinthe	5 kilogrammes.
Alcohol, 85°	20 litres.

Digest fifteen days.

Tincture of Hyssop.

Dried tops and flowers of hyssop	5 kilogrammes.
Alcohol, 85°	20 litres.

Digest fifteen days.

Tincture of Galangal.

Bruised roots of galangal (*maranta galanga*)	750 grammes.
Brandy of good flavor, 45° . .	20 litres.

Digest fifteen days.

Tincture of Balm (Infusion de Mélisse).

Dried leaves of balm . . .	5 kilogrammes.
Alcohol, 85°	20 litres.

Digest fifteen days.

Tincture of Bay (Infusion de Laurier).

Leaves of sweet bay (*laurus nobilis*)	5 kilogrammes.
Brandy of good flavor, 45° . .	40 litres.

Digest fifteen days.

Tincture of Black Currant Leaves (Infusion de Feuilles de Cassis).

Fresh leaves of the black currant (*ribes nigrum*)	5 kilogrammes.
Alcohol, 85°	20 litres.

Digest one month.

Tincture of Black Currants (Infusion de Cassis).

Among the tinctures prepared in the cold way, the tincture of black currants is the most important, on account of the great quantity used by the liquorist, and it should, on that account, attract especial attention.

It is difficult to indicate the precise quantity of currants which ought to be used in preparing this tincture. The quantity is dependent on the quality of the article it is desired to produce, or the character and condition of the fruit.

If, for example, a highly colored tincture is wanted, the process is as follows:—

Crush the currants with the feet, or in a mill prepared for the purpose, put them in a cask of medium size (200 or 300 litres) so as to fill it about two-thirds; let it stand for three or four days without disturbing it; then add alcohol (85°) enough to fill the cask; stir the whole thoroughly with a strong spatula once a day, for at least eight days, frequently drawing off the liquid from the bottom of the cask, and pouring it back into the cask. This tincture will not be fit for use in less than six weeks.

Casks of medium size are preferable for this preparation, as having many advantages over the pipes and large hogsheads generally used. In fact, in the latter, the currants being in too large quantity to be stirred up well, become impacted in masses. The liquid most frequently cuts out channels for itself through the body of the marc, or along the walls of the hogshead, without taking up the coloring matter of the fruit. Experience has proven to us that by filling a cask of 600 or

800 litres with currants, the tincture produced is inferior to that prepared as we have advised above.

If, on the contrary, it is desired to have a preparation in which the flavor of the fruit will predominate rather than the color, the crushing and *vatting* of the currants will be dispensed with. It will be necessary only to introduce the fruit into a cask and cover it with alcohol at 58 degrees.

A colored and perfumed tincture may be prepared by crushing the currants, and only filling the cask half full of the fruit, then allowing it to stand twenty-four hours, and then entirely filling the cask with alcohol at 58 degrees.

The tincture of currants may be recharged several times with fresh alcohol; in this case we use the terms *first* or *virgin infusion*, *second*, *third infusion*, &c., according to the order of the recharging.

When the *first* infusion has been made with alcohol at 85°, as that intended for *cassis double* (*ratafia*), the second charge should be made with alcohol at 58°; the third with alcohol at 43°; and finally, the fruit should be exhausted with pure water. If, on the other hand, the first charge has been with alcohol at 58°, the second charge should be with alcohol at 49°, and the third with alcohol at 43°, &c.

The exhausted marc of currants should be distilled over the naked fire, to recover the small proportion of alcohol which it may retain. The product will be put with the backings or phlegm resulting from the different distillations.

There is really no positive rule for the manufacture of *cassis;* all depends on the experience and skill of the operator.

Even by employing with the most scrupulous attention the proportions we have indicated above, it may happen that a liqueur made at one time may be greatly inferior to a liqueur prepared before or afterwards; the condition of the fruit, its ripeness, the influence of temperature, and an infusion prolonged for a greater or less

time, are causes which may lead to marked differences in quality.

If our readers should find themselves in difficulty on account of scarcity of fruit, we should advise them to adopt the following receipt:—

Cassis Ordinaire (100 *litres*).

(Proportion of pure alcohol, 21 litres, 25 centilitres, or 25 litres at 85 degrees.)

Tincture (or infusion), first charge, at 50°	18 litres.
Rousillon wine (or from Loire) .	7 "
Alcohol, at 85°	14 "
Decolorized and well clarified raw sugar	12 kilog., 500 grms.

Water, a sufficient quantity to make up the measure.

Cassis Demifin (100 *litres*).

(Proportion of pure alcohol, 23 litres, 80 centilitres, or 28 litres at 85 degrees.)

Infusion, first charge . . .	23 litres.
Wine of Loire (or Rousillon) . .	8 "
Infusion of black cherries . .	3 "
Infusion of raspberries . . .	3 "
Alcohol, 85°	13 "
Decolorized raw sugar . . .	25 kilogrammes.

Water, enough to complete the quantity.

The *cassis fin* and *surfin* being sold at a price which is sufficiently high, we should advise the use of the receipt we have already given.

We would not advise liquorists to use the syrups of starch and glucose in superfine (*surfines*) liqueurs. We have already remarked that they do not add to the quality of liqueurs.

Tincture of Raspberries (*Infusion de Framboises*).

Raspberries (very ripe) . . .	100 kilogrammes.
Alcohol, 85°	100 litres.

Digest one month before using.

Tincture of Black Cherries (Infusion de Merises).

Black cherries (very ripe) . .	100 kilogrammes.
Alcohol, 85°	100 litres.

Digest one month before using.

Tincture of Walnut Hulls (Infusion de Brou de Noix).

Green walnuts (when the kernel is just formed)	100 kilogrammes.
Alcohol, 58°	100 litres.

Crush the nuts with a pestle, suffer them to become brown by exposure to the air for twenty-four hours or more, if this is necessary to produce a very decided color; then cover them with the alcohol, and allow them to digest for three months before using.

The *pulpy* nuts, that is, those which can be easily pierced with a pin, are to be preferred; the flavor is more delicate than that of the hull of the full-grown nut; the latter may, however, be used if the others cannot be had.

The infusion of walnuts should be old; that which has been prepared for many years is preferable to the new; it is very much disposed to deposit a sediment in liqueurs, notwithstanding all the care that may be taken with the sizing and filtering.

Raspberry Vinegar (Infusion de Vinaigre Framboisé).

Raspberries (thoroughly ripe) .	100 kilogrammes.
Wine vinegar, best quality . .	100 litres.

Digest two months, stirring occasionally; draw off the clear portion and filter, then bottle it and keep it in a very cool place, *laying on the side.*

The infusions of *whortleberries* and *elderberries* are prepared as follows:—

Mash any quantity of the ripe berries with one-twentieth of their weight of water (100 kilogrammes of berries to 5 litres of water), and allow them to ferment for three or four days, according to circumstances, in a place having a temperature of 15 or 20 degrees Centi-

grade; strain with pressure, and add one-tenth of the volume (of the liquid) of spirts of wine at 85°, filter, and put in barrels or bottles.

The use of spirits of wine may be dispensed with, if the fermented juice is properly bottled and wired, and subjected to the process of Appert (heating by steam in a closet); in this case the color will not be so deep nor so fine.

These last *infusions* are employed by some liquorists to increase the color of certain liqueurs prepared from red fruits, as well as the syrups of red currants, mulberries, &c.

Remarks.—All the preparations described in this chapter, as made by the cold process, may be recharged several times with fresh alcohol, as they may still possess color or perfume. Those made from fruits, the infusion of nuts excepted, deteriorate by becoming old; the color becomes yellowish and the perfume is changed; all the others, however, improve by keeping.

CHAPTER XXIV.

LIQUEURS.

The name *liqueurs* is generally applied to certain alcoholic drinks prepared by distillation, infusion, or some other operation. Liqueurs prepared by distillation have the advantage of yielding a product charged with all the aromatic principle of the perfuming material, and yet deprived of free volatile oil, which causes sharpness in liqueurs and disturbs their transparency.

Liqueurs prepared by infusion, or from the essences, never possess the delicacy of flavor and perfume which distinguish those that are distilled, with the exception, however, of the liqueurs prepared from red fruits by infusion, and designated as *ratafias*.

All liqueurs without exception consist of alcohol,

sugar, water, and a perfume or aroma extracted from various substances, all in proportions which vary according to the quality of the article it is desired to produce.

Their hygienic properties have been and are still the subject of active controversy. Have liqueurs and spirits in general been useful or injurious to mankind? May they not, under certain circumstances, replace other medicines? Are they not, on the contrary, dangerous, and even fatal? Such are the questions which for two hundred years have divided the doctors and the various schools of moralists. It is certainly none of our business to undertake the solution of so serious a question, yet we may be permitted to say that we recognize some truths on both sides.

Without doubt, the immoderate use of spirits, and even liqueurs, is pernicious; it degrades the man and undermines his health. Intemperance, which is contrary to reason, is all the more to be feared when it appears to be the most agreeable; it deranges all the functions of organic life, attacks the stomach and the brain, and leads to an inevitable and premature old age. Like the brute, the drunkard is without consciousness; the generous sentiments of human nature are unknown to him; overcome by drink, he only lives and thinks for and by it, and often madness or *spontaneous combustion* terminates the existence of a wretch who is unworthy to live.

Nevertheless, it is well settled, and nobody can deny that while the abuse of spirits and liqueurs is pernicious, the moderate use of them may be highly salutary:—

> "*Paucula non lædunt pocula, multa nocent.*"
> "Who drinks a little, does well;
> Who drinks too much, does ill."
> *School of Salernum.*

Taken with moderation and at proper times, especially after a meal, liqueurs strengthen the stomach and assist digestion. The action of these liquids is manifested throughout the whole economy, especially in the organs of the circulation, and in the sensitive and intellectual

motors. "Impressing the organ of taste by their strength," says Brillat Savarin, "and that of the smell by the perfumed odors that are united in them, liqueurs for the moment constitute the *ne plus ultra* of the pleasure of taste."

Therapeutics, too, receives some aid from spirits and liqueurs; for example, Carmelite water (*eau des Carmes*), vulnerary waters, the elixir of Garus, &c. In fact, are not liqueurs which are composed of sugar, alcohol, and plants or drugs daily used as remedies—nothing more than medicines in a pleasant form? Are not aniseed, coriander, absinthe, hyssop, lemon, orange, orris, vanilla, cinnamon, and cloves administered every day to the sick? Is not sugar itself a powerful promoter of digestion? And besides, the small quantity of alcohol which enters into the preparation of liqueurs can in no degree be injurious to persons in good health.

The manufacture of liqueurs requires various operations, the objects of which are to arrange and prepare in advance everything required for their composition. The quality and transparency depend as much on the care which is expended on these preliminary operations, as on the selection of the materials employed in the manufacture.

We shall now describe all these operations under the light of an extended practical experience.

Compounding.

As has already been said, all liqueurs have for their foundation alcohol, sugar, and water; to which are added one or more aromatic principles.

The quality of the composition depends on the more or less intimate blending of the various substances employed, that each of them may be found in proper proportion.

Two principal rules must be observed in the preparation of liqueurs:—

1. Place the various materials which compose them in such relations as will enable them to combine readily and as promptly and intimately as possible.

2. During the operation, preserve the properties of each substance.

In order to obtain these results, it is indispensable to use spirits, sugar, and aromatic substances of the best quality, and to mix them with discretion. Liqueurs ought, too, to be *mellowed* (*trancher*), in order to deprive them of the harshness which results from the manufacture. They are to be colored, sized, and filtered, in order that they may satisfy the eye, the taste, and the nose; and finally, they must be preserved with the greatest care.

Perfume.

The talent of the liquorist consists mainly in knowing how to unite the various perfumes of liqueurs properly, so as to have his products always of the same quality.

It is not enough that he has receipts for liqueurs; he must also know how to avail himself of the plants, seeds, roots, &c., which come from every land. In order to vary his productions at will, he should be acquainted with the substances which form agreeable compounds, and which may correct or increase the perfume of a liqueur.

Thus, it is often observed that an aromatic substance, when isolated, is by no means agreeable, but on the addition of some other substance the perfume is developed and rendered more perfect. It is on this principle that a little aniseed and fennel destroy the slight boggy odor which is objectionable in the star anise; ambergris alone is almost without perfume, the least quantity of musk gives it the necessary relief; alone the quince is unpleasant, a little cloves relieves and corrects the odor; the after-taste of cinnamon is also corrected by cloves; vanilla when triturated with sugar is more aromatic than when the latter is omitted; and wormwood (*absinthe*) itself finds its place in liqueurs, provided the rind of the lemon unites its perfumes to it, so as to cover its bitterness.

The correctness of the principles we have put forth

gave rise in 1758 to a system which claimed the power of producing as many liqueurs as there are musical airs.

M. Le Camus, in his work entitled *La Médecine de l'Esprit*, had already thought that it would be possible to arrange a music of flavors analogous to the music of sound; the author of *La Chimie du Gout et de l'Odorat* has developed this idea, and as it may be more useful than would appear at first glance, we will reproduce in a few words the opinion of the author.

"The charm of liqueurs," says he, "depends on the flavors being mixed in harmonious proportions. Flavors consist in the more or less intense vibrations of salts which act on the nerves of taste, just as sounds are produced by vibrations in the air which act on the nerves of hearing; there may be, then, a music for the tongue and the palate, as there is a music for the ear. It is very probable that flavors, in order to excite different sensations in the mind, have, like sonorous bodies, their generating dominant notes—major, minor, grave, acute tones; even intervals, and, in fact, all that may produce concords or discords.

"These flavors are—1, acid, *ut;* 2, heavy, *re;* 3, tart, *mi;* 4, bitter, *fa;* 5, sweet, *sol;* 6, harsh, *la;* 7, pungent, *si*.

"In the music of flavors, the thirds, fifths, and octaves produce the most pleasant concords, precisely as in the music of sound. Mix the acid and sweet which answers to *ut* . . . . *sol*, 1 . . . 5, lemon, for example, with sugar, and you have a simple, but most charming concord—a major fifth. Mix the acid with the tart or sub-acid, as the juice of the bigarade orange with honey, for example, and you will have a tolerably pleasant flavor analogous to *ut, mi* 1. 3 . . . . , a major third. Mix the sweet with the pungent, and the concord will be less pleasant. To render it more agreeable, raise or lower one or other of the flavors half a tone, answering to the flats and sharps, and you will discover a marked difference, etc.

"The discords are not less similar in either species of music; in the music of sound, the fourth is a disagree-

able cacophony; in the music of flavors, the mixture of acid with bitter, of vinegar with wormwood, produces an abominable compound. In a word, I look on a well prepared liqueur as a species of musical air."

The perfumed spirits and waters, volatile oils, aromatic tinctures and infusions, are the various preparations which impart perfume to liqueurs. Care should be taken to have the laboratory sufficiently supplied, in order that various kinds and qualities of liqueurs may be prepared as they are called for.

Although we may give receipts with the utmost exactness, it may happen that a liqueur prepared at one time will be inferior to the same liqueur prepared at another, either because the materials which compose it are not found in the same conditions of temperature, of maturity, dryness, or moisture, or from causes which would often be difficult of explanation. Under these circumstances, the liquorist should avoid this inconvenience by adding perfume enough to produce a liqueur which may sustain a comparison with one prepared under favorable circumstances.

Mixing.

This, the most important operation of all those which are required for the manufacture of liqueurs, should be conducted in a vessel capable of being closed hermetically. The *can*, of which we have already given a description, is ordinarily employed for this purpose. This vessel contains on its interior side a scale which indicates during the mixing the quantities of syrup, water, and spirits which are poured into it, and, by this means, no errors can be made in the proper proportions of these liquids.

The mixture should always be made cold, as heat may evaporate a portion of the aromatics and spirits which it is important to preserve.

It should be observed that sugar dissolved by the aid of heat, that is to say, in the form of a more or less concentrated syrup, is infinitely preferable to that dissolved cold; the latter does not communicate to liqueurs

the softness and obscure flavor which, by covering, as it were, that of the spirit, renders liqueurs more delicate, finer, and more palatable. It is true, that by the simple solution of the sugar in cold water, each of its molecules is rendered fluid; but the fluid in which they float is not uniformly charged, and, moreover, whatever may be the constituent principles of the sugar, they are not separated and expanded as they are in sugar dissolved by heat.

The mixture is made as follows:—

First pour the perfumed spirit into the can; then, according to the liqueur to be prepared, add the spirit without perfume; stir well with a wooden spatula; then pour in the syrup, and agitate again; finally, add the necessary quantity of water, and stir for some minutes to render the mixture as complete as possible. When this operation is completed the coloring is added—care being taken to stir anew.

Rest is favorable to liqueurs, and it is only after two or three days that it can be determined by the taste whether they are sufficiently perfumed and mellow, and whether it is necessary to retouch them to improve them.

Mellowing. (Tranchage.)

Like all other spirits, liqueurs by growing old acquire a softness and delicacy which are so much relished by amateurs. As a substitute for the action of time, and to communicate the appearance of the desired age, the operation of mellowing (*tranchage*) has been invented; the operation is as follows:—

Place the liqueur in a water-bath of sufficient size to be only two-thirds full; fit on the cap, and place the water-bath in the boiler; the latter should contain the quantity of water indicated for distillation; then adjust the goose-neck, and apply a very moderate heat, and as soon as it becomes impossible to bear the hand on the cap at the origin of the goose-neck, the fire in the furnace is quickly extinguished, in order to prevent the spirits from being driven off in vapor; allow it to cool

completely before removing the water-bath from the boiler.

The heat, during this operation, produces what is called a *digestion;* it communicates to the liqueurs, by the more intimate union of the materials, a depth and uniformity of flavor which a philosopher has very correctly called that *quid infinitum* (*ce je ne sais quoi*), which renders them more pleasant.

It should be observed that the method we have indicated for perfumed spirits (p. 417) will not answer for liqueurs; as they contain sugar, the union of the materials cannot be effected by cold.

With the assistance of M. Egrot, we have constructed an apparatus for mellowing (Fig. 14), which will be of great utility to those liquorists who do not possess a proper distilling apparatus, and who are sometimes rather hasty in endeavoring to mellow their products, thereby risking the loss of alcohol and perfume.

This apparatus may be constructed of any dimensions, and, we are convinced, will render great service to the trade.

The following is a descriptive sketch of the apparatus, which is exceedingly simple:—

Apparatus for Mellowing Liqueurs.

A. Kettle or boiler, which is filled with water up to the height of the moulding.

B. Moulding which serves to support the boiler on its furnace.

CC. Two handles for lifting the boiler.

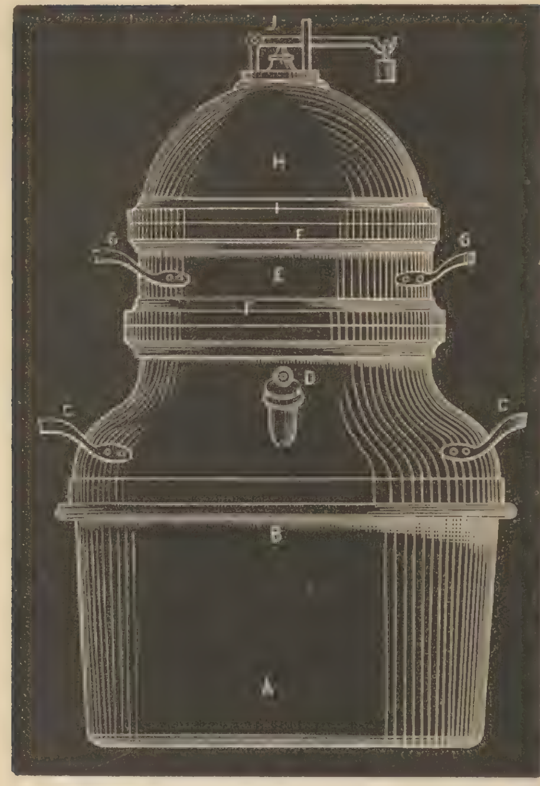
D. Screw-plug for renewing the water when the water-bath is in place.

E. Water-bath, which contains the liqueur to be mellowed.

FF. Collars to the water-bath: the lower adapted to the collar of the boiler, and is not luted; the upper is adjusted to the collar of the cap; the joint is luted.

GG. Handles of the water-bath.

Fig. 14.



H. Cap, having at its lower portion a collar, *I*, fitted to the upper collar of the water-bath.

J. Safety-valve.

Coloring.

Distilled liqueurs when sweetened with white sugar are colorless; in this condition they are as pleasant and as good as when colored, and may receive any desired color; nevertheless, under some circumstances, the coloring cannot be of service in the manufacture of liqueurs; and frequently the coloring materials alter and destroy the various perfumes which enter into their

composition, especially those which will produce the deeper tints.

The colors most generally used are, yellow from the lightest to the darkest shade, the reds, green, and violet. Such a trifling commercial artifice as the different colorings, is an excuse for varying the name of the same liqueur; on account of the necessity of covering the yellow tint caused by the use of brown sugars; and finally, to please the fancy of certain consumers, who experience as much satisfaction in the variety of colors as in the diversity of flavors.

We have already indicated the change produced by time in the infusions of red fruits; this alteration also occurs in liqueurs compounded with these infusions, and as yet we know of no means by which the inconvenience can be avoided; it is very certain that any attempts to remedy the evil only result in changing the color of the liqueurs still more.

As to liqueurs colored yellow by an infusion, they are liable to become darker by age, and may receive certain shades which will render their original color more pleasant or change it altogether.

The coloring of superfine liqueurs should be applied only after they have been *mellowed*, for this operation will positively destroy the brilliancy and beauty of the colors. It is also indispensable to add a small quantity of a solution of alum (15 grammes dissolved in a glass of water, to the hectolitre) to a colored liqueur, in order that the color may not change.

Sizing (Clarifying).

Transparency is one of the essential conditions in the manufacture of liqueurs, for it is as important in rendering them acceptable as the proper proportions of perfume, alcohol, and sugar. Indeed, when a vinous or spirituous liquor is met with in a muddy or clouded condition, whatever merit it may possess, even if it be *lachryma christi*, the first impression will be unpleasant, and even where the real quality of the liqueur is recognized by

the taste, there will still remain a sentiment of regret that the proper transparency is lacking: moreover, a muddy liquid almost always indicates that it has been badly prepared, and the foreign substances which affect its transparency frequently communicate to it an unpleasant flavor.

The design of *sizing* is to obviate the objections we have just indicated; for although liqueurs will in time clarify themselves, this operation is indispensable.

Various substances are used for sizing; viz., albumen or the whites of eggs, isinglass (fish glue), gelatine, and milk.

When one hectolitre of liqueur is to be sized with albumen, the operation is as follows:—

Take the whites of three eggs, whip them up with one litre of water, pour the whole into the liqueur, mix thoroughly, and allow it to stand twenty-four or forty-eight hours.

This sizing is adapted to those liqueurs which have a troubled or milky appearance in consequence of the partial separation of volatile oils or resinous substances; it may also be applied to liqueurs prepared by infusion, being careful, however, to diminish the quantity of white of eggs two-thirds, because the albumen attacks the color and renders it pale.

Fish size is used as follows:—

Take ten grammes of fish glue, cut in small fragments with a knife or broken with a pestle, and dissolve it in a small quantity of white wine or water, to which a little vinegar has been added, whip it from time to time, adding a little white wine or vinegar and water until the quantity amounts to one litre; after the solution is completed, pour this size into the liqueur, and stir for two minutes; allow it to rest for several days.

This method of sizing is to be preferred for highly spirituous liqueurs.

Gelatine size is prepared by dissolving thirty grammes of this substance in one litre of water, which should be heated; add to the liqueur, mix thoroughly, and permit it to stand several days.

Gelatine is proper for white liqueurs, and those which contain but a small proportion of alcohol.

Milk also is used successfully for the clarification of semitransparent and slightly alcoholic liqueurs; for this purpose, one litre of milk is boiled and poured directly into the liqueur, thoroughly stirred, and fifteen grammes of alum dissolved in a glass of water added; stir again, and allow to stand several days. If, however, the liqueur operated on has been artificially colored, it will be necessary to omit the alum, because the liqueur will already contain an equal quantity of alum intended for fixing the color.

The quantities of fish glue, gelatine, and milk, which we have indicated, are intended, as in the case of albumen, for one hectolitre of liqueur.

The acetate (sugar of lead) or the subacetate of lead (the extract of lead) is a dangerous substance for clarification, and is unfortunately used by some liquorists, because it succeeds well in accomplishing the object. In addition to this practice being most objectionable, those who apply it risk a criminal prosecution for the offence.

Some who are more scrupulous, after having treated a liqueur by the acetate or subacetate of lead, neutralize these salts by the use of the same quantity of tartaric acid, which, by forming an abundant precipitate, throws them to the bottom. The quantities employed for a hectolitre of liqueur are generally as follows: acetate or subacetate of lead, 100 grammes; tartaric acid, 100 grammes.

The presence of a salt of lead in any liquid is readily detected by adding to it a few drops of a solution of sulphate of soda (5 grammes of the sulphate dissolved in 15 grammes of water), or an alcoholic solution of picromel (alcohol 15 grammes, picromel 2 grammes).

Liqueurs are sometimes sized when hot, that is to say, at the time of mellowing, the whites of a dozen of eggs are added to a hectolitre of liqueur; this method is objectionable, because the liqueur so treated acquires the flavor of cooked albumen, which even time will scarcely dissipate.

For reasons deducible from what has been set forth in this article, after the liqueurs have been clarified by sizing and rest, it is still proper to filter them, in order to produce a perfect state of transparency.

NOTE.—For superfine Curaçoas we would advise, as a consequence of numerous experiments, the use of one litre of pure boiling milk to the hectolitre, agitating it vigorously in the cask or can, and allowing it to rest as long as possible before filtering.

Filtering.

Filtering consists in passing and repassing, as often as may be necessary, a liquid through the pores of a substance pervious to liquids only, and almost absolutely impermeable to solids even in the finest state of division. This result is obtained by means of a conical bag or pocket of woollen stuff lined with *filtering paper*, or with the latter only.

The operation by means of the bag is conducted as follows:—

Attach a very clean woollen bag to the hooks on the interior of the copper filter, then pour into it a portion of the liqueur, having first closed the stopcock at the bottom of the filter, take three or four sheets of filtering paper, which have first been reduced to a pulp in a mortar with a little water, and mix them with another portion of the liqueur in a basin, then pour this mixture into the bag; fill the latter entirely with liquid, and receive the liquid which flows off in a pan (of sheet tin or tinned copper); return the liqueur several times into the filter, being careful to pour it in a gentle stream as near the middle as possible, and keep the bag always full. When the liqueur runs clear, collect in a clean can or jar, and store it in casks or bottles, as may be desired.

In order to avoid the necessity of keeping the arm constantly extended with a basin of liqueur to feed the filter, a can containing the liqueur may be placed above the filter (see plate IX., figs. 14 and 15), having a cock at the bottom, and by opening this so as to admit a stream

proportional to that from the filter, the operation will scarcely require any personal supervision.

If, in consequence of circumstances, which, by the by, must be avoided as much as possible, it becomes necessary to filter a liqueur as soon as it is compounded, two or three more sheets of paper must be used, and in the event of the liqueur being milky, in consequence of floating particles of undissolved volatile oil, a small quantity of powdered animal black must be added to separate the excess of oil. This method, however, must not be abused, because the liqueur will thereby lose a portion of its perfume. It is to be understood that animal black can be used only with white liqueurs, its decolorizing properties forbidding its use with those that are colored; a little powdered alum may be proper under these latter circumstances.

As has been said above, the bags are conical pockets, which should be made of a twilled woollen goods called swanskin (*molleton de laine*); the bags made of felt, as used by the wine merchants, are not suitable for the purposes of the liquorist.

A number of bags should always be kept on hand, so as not to filter a white liqueur through a bag which has been used for one that is colored, or containing a perfume which may be injurious to it. The bags must be well and carefully washed without beating them, but simply by dipping them frequently in many waters, in order not to remove the nap of the cloth, which is necessary for the proper adhesion of the pulped paper used in after operations. When the bags are well dried, it is important to keep them in some place thoroughly protected from dust of all kinds.

Filtering paper is an unsized paper; it is white, gray, or reddish gray; the latter is to be preferred. The quality of this paper is tested by its softness and flexibility, or when touching it to the tongue the moisture strikes through at once; it must be examined carefully, to see if there are threads of wool, or if, when holding the sheets to the light, there are thin places which may give way under the pressure of the liquids to be filtered.

Filtering by paper alone is adopted only when small quantities of a liqueur are to be operated on; the filtering paper is made into the form of a funnel; to effect this, a square sheet of paper is folded in four parts, then each of these is folded into four parts, so as to form a fan folded into sixteen parts; the upper portion, which is uneven, is cut off, then the doubled sheet is opened into the form of a cone. The filter is then placed in a glass funnel, care being taken to sink it as low as possible in the funnel, so that the bottom of the filter will not have too large a surface unsupported; the weight of the liquid, being in proportion to the surface, may tear it. The funnel is placed on a jar or bottle, and the liquid poured on the filter: the first portions of the filtered liquid are passed through the filter a second time, if necessary.

Storing and Preservation of Liqueurs.

Whatever attention may be given in all the departments of the manufacture of liqueurs, as well as in the selection of the materials which enter into their composition, it is rare that these liquids are perfect immediately after their preparation; time, mellowing, and every precaution taken for their preservation, only produce this desirable result.

Liqueurs should be kept in some place which has an almost constantly equable temperature (15° or 20° Centigrade), and, as has been said before, as remote as possible from the noise and jar of workshops and passing vehicles.

The sun and daylight act energetically on liqueurs. Sunlight destroys their color, and precipitates it to the bottom of the bottles; Swiss absinthe, which has for some time been subjected to its action, acquires a very decidedly rancid taste. Daylight also attacks colors, and causes them to deposit.

Barrels or casks for large quantities, and stone jugs for small, are infinitely better for the preservation of liqueurs than vessels of tinned copper or glass bottles; and finally, as a general rule, liqueurs improve more in quality when in large vessels than in small ones.

Classification of Liqueurs.

Liqueurs which are prepared by distillation (or maceration), or by the solution of the essences, are divided into four principal classes: common (*ordinaires*), half-fine (*demi-fines*), fine (*fines*), and superfine (*surfines*) liqueurs.

The third fine (*liqueurs teirs-fines*) liqueurs are known only in the city of Paris; they are prepared by mixing the common and half-fine in equal parts.

Double liqueurs (*liqueurs doubles*) are manufactured everywhere else in France except in Paris; and the suburbs of the city ship them in considerable quantities.

The classification of liqueurs depends on the proportions of alcohol, perfume, sugar, and water employed in the manufacture, as well as in the care given to their preparation.

The names *waters* and *oils* (*eaux et huiles*) are applied more particularly to common (*ordinaires*) liqueurs; there are, however, some liqueurs of superior quality which are also known by these names. The names creams and elixirs (*crèmes et élixirs*) are given almost exclusively to fine and superfine liqueurs. These last are further divided into several kinds, as French, foreign, and West Indian liqueurs (*Française, etrangères et des îles*). The *ratafias* are liqueurs composed of infusions of fruits or aromatic substances.

As for the names peculiar to each liqueur, the variety is infinite, and we cannot pretend to indicate all of them; moreover, the originality and eccentricity of some names, such as *esprit de Chateaubriand, d'Abd-el-Kadir, de Napoleon, liqueur de la polka, de la Couronne,* no matter what, &c., proves that they have nothing serious or fixed in them, but are only a matter of fancy; a new and highly colored label and a different tint transform almost any known liqueur into something new. We shall confine ourselves, therefore, to the receipts for such liqueurs as are well known, and are in demand by the public.

Nomenclature and Receipts for Liqueurs by Distillation.

Common Liqueurs.

The proportions of alcohol and sugar for common liqueurs are the same, viz., 25 litres of alcohol at 85°, allowance being made for the quantity of perfumed spirit, and 12 kilogrammes, 500 grammes of sugar, for each hectolitre of liqueur; the quantities of water and perfume being variable.

The quantity of alcohol we have indicated may, perhaps, appear to be too small. It is that, however, which is most generally employed. Nevertheless, when *trois-six* is at a low price, this proportion may be increased two or three per cent. as a maximum.

If, instead of dissolving the sugar as it is required in the manufacture, syrups prepared in advance are used, as is done in large establishments, it will be necessary to reduce the quantity of water which we indicate so as to place it in proper proportion to the syrup used. Thus, suppose that the syrup weighs 34°, on consulting the table (page 389) we observe that a litre of this liquid contains 850 grammes of sugar; it will require, therefore, 14 litres and 70 centilitres of syrup to represent the 12 kilogrammes, 500 grammes of sugar called for, and, consequently, only 60 litres and 30 centilitres of water for the operation. This example being well understood, we may dispense with others.

The use of syrups prepared in advance enables the liquorists to profit by the richness of a sugar, and to furnish liqueurs always of equal sweetness; while, on the other hand, by employing a dose of raw or refined sugar, the result is not constantly the same.

Certain liquorists who sell their goods at a very low price employ syrup of starch to partially sweeten their common and demi-fine liqueurs; others add this syrup, not for the purpose of economizing sugar, but to impart a thicker and more oily appearance to their liqueurs. The following are the doses employed by the last-named: 9 kilogrammes sugar, and 6 litres (7 kilogrammes, 500 grammes) of white syrup of starch.

It is known that a common liqueur contains the proper quantity of sugar when it marks 5° on the saccharometer.

Anisette, or Eau d'Anis.

Spirit of anise (*ordinaire*) .	5 litres.
Alcohol, 85°	20 "
Sugar	12 kilog., 500 grms.
Water	66 litres.

Place the spirit of anise and the alcohol in a can; add the sugar, dissolved by heat, in a portion of the water; then complete the manufacture by pouring in the balance of the water; size, and after a sufficient rest, filter.

Eau d'Angelique.

Spirit of angelica (roots) . .	8 litres.
Alcohol, 85°	17 "
Sugar	12 kilog., 500 grms.
Common water	63 litres.

The operation is the same as the last.

Cent-Sept-Ans.

Spirit of lemon . . .	1 litre.
Rose water	3 litres.
Alcohol, 85°	24 "
Sugar	12 kilog., 500 grms.
Common water	63 litres.

Colored red with orchil; process as last.

Curaçoa.

Spirit of curaçoa (common) .	8 litres.
Alcohol, 85°	17 "
Sugar	12 kilog., 500 grms.
Water	66 litres.

Color a deep yellow with caramel, or a small quantity of the coloring for demi-fine curaçoa. Process as above.

Fleurs d' Oranger.

Orange-flower water . . .	6 litres.
Alcohol, 85°	25 "
Sugar	12 kilog., 500 grms.
Water	60 litres.

Process the same as for anisette.

Framboises.

Spirit of raspberries . . .	10 litres.
Alcohol, 85°	15 "
Sugar	12 kilog., 500 grms.
Water	66 litres.

Color red with orchil, and proceed as above. A *ratafia* of raspberries is also made by infusion or maceration.

Mint.

Peppermint water . . .	8 litres.
Alcohol, 85°	25 "
Sugar	12 kilogs., 500 grms.
Water	58 litres.

Proceed as for anisette. This (*ordinaire*) liqueur is not so pleasant, because the perfume requires much sugar.

Eau de Noyaux.

Spirit of apricot seeds . .	9 litres.
Alcohol, 85°	16 "
Sugar	12 kilogs., 500 grms.
Water	66 litres.

Process as above.

Parfait Amour.

Spirit of lemon . . .	2 litres.
" coriander . . .	2 "
Alcohol, 85° . . .	21 "
Sugar	12 kilogs., 500 grms.
Water	66 litres.

Color red with orchil, and proceed as above.

Huile de Roses.

Rose water	6 litres.
Alcohol, 85°	25 "
Sugar	12 kilogs., 500 grms.
Water	60 litres.

Color red with orchil, and proceed as above.

Eau des Sept-graines.

Spirit of dill (*aneth*)	1 litre, 25 centilitres.
" angelica (seeds)	2 litres.
" anise	2 "
" celery	2 "
" skirret (*chervi*)	1 litre.
" coriander	2 litres.
" fennel	1 litre.
Alcohol, 85°	14 litres.
Sugar	12 kilogs., 500 grms.
Water	66 litres.

Color a bright yellow with caramel, and proceed as above.

Vespetro.

Spirit of muskmallow (*ambrette*)	50 centilitres.
" dill	1 litre.
" anise	2 litres.
" caraway	2 "
" coriander	2 "
" candy carrot (*daucus*)	1 litre.
" fennel	2 litres.
Alcohol, 85°	14 litres, 50 centils.
Sugar	13 kilogrammes.
Water	66 litres.

Proceed as above. This liqueur is sometimes preferred of a bright yellow. In this case add a little caramel.

Remark.—In the preparation of common (*ordinaire*) liqueurs, the perfumed spirits may be replaced by aromatic distilled waters and *vice versa*, in which case, the difference in the quantity of alcohol must be taken into account, so that the liqueurs shall always contain 25 per cent. of alcohol at 85°.

Liqueurs Doubles.

As with the preceding liqueurs, the proportions of alcohol and sugar are invariable for double liqueurs, and also, as is stated, for one hectolitre of liqueur, viz., 50 litres of alcohol at 85° and 25 kilogrammes of sugar. As for the perfumes, the proportions vary according to the substances which furnish them.

It must be observed that the double liqueurs, which in theory should contain a dose of perfume double that of the common liqueurs, cannot, as a general rule, contain this quantity. These liqueurs being destined to be reduced one-half by the addition of clear water, so that a litre of double liqueur shall form two, if the dose of perfume is doubled, the liqueur so reduced will acquire a milky tint, due to the excess of volatile oil thrown out of solution, and will thus become unpleasant to the eye. By following our receipts, this inconvenience will be avoided.

Anisette or *Eau d'Anis.*

Spirit of aniseed	8 litres.
Alcohol, 85°	42 "
Sugar	25 kilogrammes.
Water	33 litres.

Proceed as for *anisette ordinaire.*

Eau d'Angelique.

Spirit of angelica (seeds)	14 litres.
Alcohol, 85°	36 "
Sugar	25 kilogrammes.
Water	33 litres.

Process as above.

Cent-Sept-Ans.

Spirit of lemon	1 litre, 50 centils.
Rose water	6 litres.
Alcohol, 85°	48 litres, 50 centil.
Sugar	25 kilogrammes.
Water	27 litres.

Color a decided red with orchil, in order that the di-

luted liqueur may have a color similar to that of the *cent-sept-ans ordinaire.*

Proceed as above.

Curaçoa.

Spirit of curaçoa (common) . .	10 litres.
Alcohol, 85°	40 "
Sugar	25 kilogrammes.
Water	33 litres.

Color a deep yellow with caramel, adding a little of coloring for demi-fine curaçoa, and proceed as above.

This double liqueur is one of those which is least preferred, on account of the facility with which the volatile oil of orange peel is thrown out of solution by reducing it with water.

Fleur d' Oranger.

Orange-flower water . . .	10 litres.
Alcohol 85°	50 "
Sugar	25 kilogrammes.
Water	23 litres.

Process same as for anisette.

Framboises.

Spirit of raspberries . . .	16 litres.
Alcohol, 85°	34 "
Sugar	25 kilogrammes.
Water	34 litres.

Color a deep red with orchil, and proceed as above.

Huile de Menthe.

Peppermint water	12 litres.
Alcohol, 85°	50 "
Sugar	25 kilogrammes.
Water	21 litres.

Process same as for anisette.

Eau de Noyaux.

Spirit of apricot seeds . . .	14 litres.
Alcohol, 85°	36 "
Sugar	25 kilogrammes.
Water	33 litres.

Process the same as the last.

Parfait Amour.

Spirit of lemon	1 litre.
" coriander . . .	6 litres.
Alcohol, 85°	43 "
Sugar	25 kilogrammes.
Water	33 litres.

Color a decided red, and proceed as above.

Huile de Roses.

Rose water	12 litres.
Alcohol, 85°	50 "
Sugar	25 kilogrammes.
Water	21 litres.

Proceed as above.

Eau des Sept-graines.

Spirit of dill (*aneth*) . . .	1 litre.
" angelica (seeds) . .	1 "
" anise	2 litres.
" celery	1 litre.
" chervi	1 "
" coriander . . .	2 litres.
" fennel	1 litre.
Alcohol, 85°	41 litres.
Sugar	25 kilogrammes.
Water	33 litres.

Color yellow with caramel, and proceed as above.

Vespetro.

Spirit of muskmallow . . .	1 litre.
" dill	1 "
" anise	2 litres.
" caraway	1 litre.
" coriander . . .	2 litres.
" daucus	1 litre.
" fennel	1 "
Alcohol, 85°	41 litres.
Sugar	25 kilogrammes.
Water	33 litres.

If necessary, color yellow with caramel, and proceed as above.

The remarks made at the beginning and end of the receipts for ordinary liqueurs, apply equally to *liqueurs doubles.*

Liqueurs Demi-fines.

Demi-fine liqueurs have for their foundation, like the preceding, fixed doses of alcohol and sugar, viz., 28 litres of alcohol at 85°, and 25 kilogrammes of sugar.

Anisette.

Spirit of anisette (*ordinaire*)	6 litres
Orange-flower water	1 litre.
Alcohol, 85°	22 litres.
Sugar	25 kilogrammes.
Water	54 litres.

Process as for *anisette ordinaire.*

Crème d'Angelique.

Spirit of angelica (roots)	7 litres.
" " (seeds)	7 "
Alcohol, 85°	14 "
Sugar	25 kilogrammes.
Water	55 litres.

Proceed as above.

Crème de Celeri.

Spirit of celery	12 litres.
Alcohol, 85°	16 "
Sugar	25 kilogrammes.
Water	55 litres.

Process as above.

Cent-Sept-Ans.

Spirit of lemon	2 litres.
Rose water	3 "
Alcohol, 85°	26 "
Sugar	25 kilogrammes.
Water	52 litres.

Color red with cudbear, and proceed as above.

Curaçoa.

Spirit of curaçoa (*ordinaire*)	12 litres.
Infusion of curaçoa	15 centilitres.
Alcohol, 85°	15 litres.
Sugar	25 kilogrammes.
Water	55 litres.

Color with one litre of the coloring for demi-fine curaçoa, and, if the color should be too red, reduce it to a deep yellow by a few drops of a solution of tartaric acid. If required, add a little caramel to give more body to the tint.

Crème de Fleurs d'Oranger.

Orange-flower water	9 litres.
Alcohol, 85°	28 "
Sugar	25 kilogrammes.
Water	46 litres.

Proceed as for anisette.

Huile de Framboises.

Spirit of raspberries	15 litres.
Alcohol, 85°	13 "
Sugar	25 kilogrammes.
Water	55 litres.

Color red with cudbear, and proceed as above.

Crème de Menthe.

Mint water	10 litres.
Alcohol, 85°	28 "
Sugar	25 kilogrammes.
Water	45 litres.

Proceed as above.

Crème de Moka.

Eau de Moka (coffee)	20 litres.
Alcohol, 85°	28 "
Sugar	25 kilogrammes.
Water	35 litres.

Proceed as above.

Crème de Noyaux.

Spirit of apricot seeds	14 litres.
Alcohol, 85°	14 "
Sugar	25 kilogrammes.
Water	55 litres.

Proceed as above.

Parfait Amour.

Spirit of lemon	3 litres.
" " coriander	4 "
Alcohol, 85°	21 "
Sugar	25 kilogrammes.
Water	55 litres.

Color red with cudbear, and proceed as the last.

Huile de Roses.

Rose water	10 litres.
Alcohol, 85°	28 "
Sugar	25 kilogrammes.
Water	45 litres.

Color red with cudbear, and proceed as above.

Eau des Sept-graines.

Spirit of dill	1 litre, 50 centilitres.
" " angelica (seeds)	2 litres, 50 "
" " anise	2 "
" " celery	2 "
" " chervi	1 litre, 50 centilitres.
" " coriander	2 litres, 50 "
" " fennel	2 "
Alcohol, 85°	14 "
Sugar	25 kilogrammes.
Water	55 litres.

Color a bright yellow with caramel, and proceed as above.

Vespetro.

Spirit of muskmallow . .	. 50 centilitres.
" " dill	. 1 litre, 50 centilitres.
" " anise . . .	. 3 litres.
" " caraway . . .	. 3 "
" " coriander . .	. 3 "
" " daucus . . .	. 1 litre, 50 centilitres.
" " fennel . . .	. 2 litres, 50 "
Alcohol, 85° . . .	. 13 "
Sugar	. 25 kilogrammes.
Water	. 55 litres.

If required, color yellow with caramel, with the addition of a little saffron. Process same as preceding.

Punch-liqueur.

Brandy (*eau de vie*), 58° .	40 litres.
Rum (*tafia*), 55° . . .	5 "
Concentrated spirit of lemon	10 centilitres.
Citric acid	50 grammes.
Hyson tea	. 125 "
Raw Martinique sugar . .	18 kilog., 750 grammes.
Water	42 litres.

Infuse the tea in four litres of boiling water, allow it to cool, and press; then pour the brandy, rum, and spirit of lemon into a can, add the infusion of tea, the clarified sugar and the acid dissolved in a glass of water; mix, and color with a little caramel; size, if necessary, and filter.

This liqueur must not be confounded with "the spirit of punch;" it is intended to be used cold and as prepared.

The *rum-punch liqueur* is prepared in the same way, the brandy being replaced by *rum*.

Remark.—The remarks and observations made under the head of ordinary (*ordinaire*) liqueurs, in regard to aromatic distilled waters, syrup of sugar, and syrup of starch, may be repeated in reference to demi-fine liqueurs.

The dose of alcohol may also be increased two per cent. When a demi-fine liqueur marks ten degrees on the saccharometer, it contains the proper quantity of sugar.

Fine Liqueurs (Liqueurs Fines).

Fine liqueurs, with the exception of curaçoa, are all prepared with the same quantity of alcohol and sugar; the dose of the latter varies, however, with certain liquorists according to the selling price; they use 375 grammes (12 oz.) to the litre of liqueurs, but it is better to employ the quantity we indicate (437 grammes, 50 centigrammes, or 14 ounces).

In order to avoid the constant repetition of the doses of sugar and water, we shall indicate them only in the first receipts. It must be understood that all the quantities, whatever be the character of the materials, are intended for one hectolitre of liqueur.

Anisette.

Spirit of anisette (*de Bourdeaux*)	25 litres.
Orange-flower water	1 litre.
Infusion of iris	20 centilitres.
Alcohol, 85°	7 litres.
Sugar	43 kilog., 750 grms.
Water	38 litres.

Proceed in the usual way.

Crème d'Angelique.

Spirit of angelica (roots)	10 litres.
" " " (seeds)	10 "
Alcohol, 85°	12 "
Sugar	43 kilog., 750 grms.
Water	39 litres.

Cent-Sept-Ans.

Spirit of lemon	4 litres.
" " coriander	4 "
Alcohol, 85°	24 "
Sugar and water as above.	

Color red with cudbear.

Curaçoa

Spirit of curaçoa (of Holland)	25 litres.
" orange	7 "
Infusion of curaçoa	25 centilitres.
Coloring for superfine curaçoa	4 litres.
Sugar	43 kilog., 750 grms.
Water	35 litres.

Reduce the color to a dark yellow by adding a few drops of a solution of tartaric acid. In case the operator should use the coloring prepared by boiling, or that produced by hæmatine, it will be necessary to add 4 litres of alcohol at 85°.

Eau de Vie d'Andaye.

Spirit of anise	2 litres.
" coriander	2 "
" bitter almonds	2 "
" angelica (roots)	4 "
" cardamum (large)	50 centilitres.
" " (small)	50 "
" citrons	1 litre.
" orange	5 litres.
Infusion of iris	20 centilitres.
Alcohol, 85°	15 litres.
Sugar	43 kilog., 750 grms.
Water	39 litres.

Eau de Vie de Dantzick.

Spirit of Ceylon cinnamon	2 litres, 50 centilitres.
" China cinnamon	5 "
" coriander	5 "
" cardamum (large)	50 centilitres.
" " (small)	50 "
" muskmallow	
Alcohol, 85°	18 litres.

Sugar and water the usual quantities.

It is customary to put a certain quantity of gold or silver leaf into the flasks (green or white glass) of eau de Dantzic. For this purpose one or two sheets of gold or silver leaf are put into a glaas with ten centilitres of liqueur, and the whole beaten with a fork until the metal is broken into fragments.

Crème de Fleurs d' Oranger.

Spirit of orange-flowers	10 litres.
Orange-flower water	5 "
Alcohol, 85°	22 "
Sugar	43 kilog., 750 grms.
Water	34 litres.

Crème de Framboises.

Spirit of raspberries	20 litres.
Alcohol, 85°	12 "

Sugar and water, the usual quantity.

Color red with cudbear.

Huile de Kirschenwasser.

Common kirsch, 51°	20 litres.
Spirit of apricot seeds	4 "
Orange-flower water	1 litre.
Alcohol, 85°	16 litres.
Sugar	43 kilog., 750 grms.
Water	30 litres.

Crème de Menthe.

Essence of peppermint	25 litres.
Alcohol, 85°	7 "

Sugar and water, the usual quantity.

Proceed as above.

Crème de Noyaux.

Spirit of apricot seeds	16 litres.
" bitter almonds	8 "
Alcohol, 85°	8 "
Orange-flower water	1 litre.
Sugar	43 kilog., 750 grms.
Water	38 litres.

Crème de Moka.

Spirit of moka	25 litres.
Alcohol, 85°	7 "

Sugar and water, the usual quantity.

Huile d' Œillets.

Spirit of violets	20 litres.
" cloves	1 litre.
Alcohol, 85°	11 litres.

Sugar and water, the usual quantity.

Color red with cudbear, and proceed as above.

Parfait Amour.

Spirit of lemon	3 litres.
" orange	3 "
" coriander	4 "
" anise	2 "
Alcohol, 85°	20 "

Sugar and water, as usual

Color red with cudbear, and proceed as above.

Huile de Rhum.

Common rum, 53°	30 litres.
Alcohol, 85°	14 "
Sugar, the usual quantity.	
Water	27 "

Color a decided yellow with caramel, and proceed as above.

Huile de Roses.

Spirit of roses	25 litres.
Alcohol, 85°	7 "

Sugar and water, the usual quantity.

Color red with cudbear, and proceed as above.

Eau des Sept-Graines.

Spirit of dill	2 litres.
" angelica (seeds)	3 "
" anise	3 "
" celery	3 "
" chervie	3 "
" coriander	3 "
" fennel	3 "
Alcohol, 85°	13 "

Sugar and water, the usual quantity.

Color a bright yellow with caramel, and proceed as usual.

Scubac.

Spirit of saffron . . .	1 litre, 50 centilitres.
" cinnamon (China) .	4 litres.
" cloves . . .	4 "
" nutmegs . . .	2 " 50 "
Orange-flower water . .	1 litre.
Alcohol, 85°	20 litres.
Sugar, the usual quantity.	
Water	38 "

Color an amber yellow with saffron coloring, and add a little caramel to deepen the tint. Proceed as above.

Crème de Thé

Spirit of tea . . .	25 litres.
" angelica (roots) .	50 centilitres.
Alcohol, 85° . . .	6 " 50 "
Sugar and water, the usual quantity.	

Proceed as above.

Vespétro.

Spirit of muskmallow	1 litre.
" dill	2 litres.
" anise	4 "
" caraway	4 "
" coriander	4 "
" daucus	2 "
" fennel	3 "
Alcohol, 85°	12 "
Sugar and water, as indicated above.	

Punch Liqueur.

Old Cognac brandy, 55° . .	46 litres.
Old rum, 50°	10 "
Concentrated spirit of lemons .	15 centilitres.
Citric acid	60 grammes.
Imperial tea	200 "
White sugar	31 kilog., 250 grms.
Water	23 litres.

Operate as for demi-fine punch liqueur (see p. 462).

This liqueur, which is to be consumed cold and *en nature*, must not be confounded with the syrup of punch.

Remarks.—The syrup of starch cannot be used in the manufacture of either fine or superfine liqueurs. These require the use of refined sugar.

A fine liqueur sweetened with 437 grammes, 50 centigrammes (14 ounces) of sugar to the litre, will mark 17° on the saccharometer. That sweetened with 375 grammes (12 ounces), will mark only 15°.

Superfine Liqueurs (Liqueurs Surfines).

As was said above, superfine liqueurs are divided into three kinds—French (*Françaises*), foreign (*etrangères*), and West Indian (*des îles*). These three kinds of liqueurs should be the object of the especial attention of the liquorist, and he should endeavor to give every care and attention to their manufacture.

The proportions of alcohol, sugar, and water which are to be used for superfine liqueurs being sometimes variable, we are compelled to indicate the doses for each receipt.

These liqueurs generally contain 562 grammes, 50 centigrammes (18 ounces) of sugar to the litre, and mark 25° on the saccharometer. There are, however, some manufacturers who only use 500 grammes (16 ounces) of sugar, in which case they mark 20°.

The manufacture of superfine liqueurs has been enriched since 1858 by new receipts, which we give.

The attention of manufacturers is especially called to the preparation of curaçoas (*de Hollande*), to which we have given a new value by our efforts.

If the workman will study our work well and carefully, and closely follow our methods of manufacture, we can assure him, in advance, of success; with the one condition (*sine qua non*), that he has real rinds and of the best quality.

Liqueurs Surfines Francaises.

Anisette de Bourdeaux.

Star anise (*badione*)	1 kilog., 750 grms.
Green anise (*anis vert*)	500 grammes.
Fennel	437 "
Coriander	437 "
Sassafras wood	450 "
Muskmallow (*ambrette*)	187 "
Imperial tea	190 "
Nutmegs	10 "
Alcohol, 85°	40 litres.

Macerate the whole for 24 hours in the alcohol; distill in a water bath, with the addition of 19 litres of water; rectify with the same quantity of water so as to draw off 36 litres of good quality; then dissolve 56 kilogrammes of very white refined sugar by heat in 24 litres of water; when cold, mix the liquids together, and add:—

Infusion of orris-root	50 centilitres.
Orange-flower water	2 litres.

Then pour in enough water to make one hectolitre of liqueur. Mellow, size, and after a sufficient rest, filter.

The anisette of Bourdeaux (*Anisette de Bourdeaux*) enjoys a universal reputation; the old house of Marie Brizard, prior to 1789, exported this liqueur to all parts of the world, and her successors still retain this kind of monopoly. There are, however, in Bourdeaux, and in many other cities in France, liquorists who manufacture anisettes which rival those bearing the name of *Marie Brizard*.

We have made an analysis of the genuine anisette manufactured by the successors of Marie Brizard, and find the following to be the result for one litre:—

Alcohol, 85°	32 centilitres.
Sugar	500 grammes.
Water	35 centilitres.

The saccharometer plunged into this liqueur marks 20°.

Anisette de Paris.

Star anise	1 kilog., 500 grms.
Bitter almonds	1 "
Anise	500 grammes.
Coriander	250 "
Fennel	125 "
Angelica (root)	30 "
Fresh lemon rind, number	20.
Fresh orange rind, number	20.
Alcohol, 85°	38 litres.

Distill and rectify as in the preceding receipt; then dissolve, by the aid of heat, 56 kilogrammes of refined sugar in 24 litres of water; after cooling, mix the whole and add:—

Infusion of orris-root	25 centilitres.
Orange-flower water	1 litre.
Cinnamon water (Ceylon)	50 centilitres.
Water of cloves	10 "
Water of nutmegs	10 "

Add enough water to make a hectolitre of liqueur. Mellow, size, and after a sufficient rest, filter.

Anisette de Lyon.

Star anise	1 kilog., 750 grms.
Green anise	1 "
Coriander	250 grammes.
Fennel	125 "
Sassafras wood	125 "
Angelica root	30 "
Rinds of fresh lemons, number	30.
Alcohol, 85°	41 litres.

Macerate for 24 hours and distill in a water-bath carefully, but without rectifying; draw off 40 litres of perfumed spirit; dissolve 56 kilogrammes of very white refined sugar by heat in 19 litres of water, and when cold mix the whole and add:—

Orange-flower water	2 litres.
Cinnamon water	50 centilitres.
Infusion of orris-root	50 "

Add enough water to make up one hectolitre of liqueur, and finish the operation as for *anisette de Bourdeaux.*

This anisette is just now very much in vogue; it is served at the cafés in goblets, and when water is poured into it, it becomes almost as white as Swiss absinthe.

Délices de Rachel.

Spirit of bitter almonds	14 litres.
" orange	2 "
" cinnamon (China)	2 "
" dill	2 "
" coriander	2 "
" muskmallow	1 litre.
" fennel	1 "
Rose water	1 "
Orange-flower water	1 "
Alcohol, 85°	12 litres.
White sugar	45 kilogrammes.

Color a delicate green with blue and saffron (in imitation of green chartreuse).

Crème d'Absinthe.

Dried tops and leaves of the larger absinthe	1 kilogramme.
Dried tops and leaves of the less absinthe	500 grammes.
Dried peppermint leaves	500 "
Anise	500 "
Fennel	125 "
Calamus	125 "
Fresh lemons (rind), number	10.
Alcohol, 85°	38 litres.

Macerate 24 hours; distill and rectify with the addition of the usual quantity of water, and draw off 36 litres of perfumed spirit; then, by the aid of heat, dissolve 56 kilogrammes of sugar in 26 litres of water; when cold, mix the whole together, adding enough water to make one hectolitre of liqueur.

Crème d'Angelique.

Angelica root	1 kilog., 250 grms.
Angelica seed	1 " 250 "
Coriander	125 grammes.
Fennel	125 "
Alcohol, 85°	30 litres.

Macerate, distill, and rectify as in the preceding, and add to the 36 litres of perfumed spirit 56 kilogrammes of very white refined sugar and enough water to make 100 litres of liqueur.

Elixir de Cagliostro.

Cloves	800 grammes.
Cinnamon (China) . . .	800 "
Nutmegs	800 "
Saffron	200 "
Gentian	200 "
Tormentilla	200 "
Socotrine aloes	2 kilog., 400 grms.
Myrrh	1 " 200 "
Fine treacle	2 " 400 "
Alcohol, 85°	36 litres.

Macerate for 48 hours, and distill gently to obtain 36 litres of spirit; do not rectify; add 50 kilogrammes of white sugar, dissolved by heat, in the usual quantity of water; mix, and add 15 centilitres of tincture of musk and three litres of orange-flower water, and then make up the quantity to 100 litres. Mellow, and color a golden yellow with saffron and caramel; size, and after rest, filter.

This elixir is said to be useful in cases of debility, feeble digestion, &c.*

M. Cadet (the father) says that he happened to be dining one day at the house of Cagliostro with La Harpe, Lemoine, Linguet, and the daughter of Salmon, who had been condemned to be burned alive, and who had just been pardoned by the parliament at Paris. This beautiful and interesting female was at that time the object of public curiosity; she was invited and fêted by every one. The sumptuous and frequent feasts which she had attended had so entirely disordered her stomach, that she could digest only the lightest food, and even this was sometimes rejected; a dysentery had exhausted her very much for some days. The pallor of her complexion and her languid air caused her to be questioned concerning her health. Each of them set himself to advising her to take care of herself and to be cautious

* The active principles of aloes and gentian are not volatile. The efficacy of this preparation would be increased by substituting the operation of displacement with the non-volatile drugs for distillation. It may well take the place of many of the hurtful patent medicines, *so called.—Translator.*

with her diet, when Cagliostro, raising his voice, exclaimed: "This is not my opinion; Mademoiselle may eat whatever her appetite calls for, and I will answer for her speedy restoration to health, if she will take a few drops of an elixir I will procure for her."

A servant by his order brought a vial from which the Count made the patient drink three spoonfuls; some minutes after, Mlle. Salmon's color returned and her strength was restored. We took our places at table, and she did honor to the repast, which was followed by a second dose of the elixir.

M. Cadet assured himself of the beneficial effects of the remedy by making a visit on the next day to Mlle. Salmon, and Count Cagliostro at his request furnished him with the formula.*

Crème de Celeri.

Celery seed	2 kilog., 500 grms.
Daucus of Crete . . .	125 grammes.
Alcohol, 85°	38 litres.

By the process already described, draw off 36 litres of perfumed spirit, to which add 50 centilitres of cinnamon water and 56 kilogrammes of very white refined sugar, dissolved by heat, in enough water to make 100 litres of liquid.

* The following is the genuine receipt given by Cagliostro :—

Cloves	8 grammes.
Cinnamon	8 "
Nutmegs	8 "
Saffron	2 "
Gentian	2 "
Tormentilla	2 "
Socotrine aloes	24 "
Myrrh	12 "
Musk	1 centigramme.
Fine treacle	24 grammes.
Brandy	1 kilog., 500 grms.

Digest 15 days; then filter, and add 750 grammes of the syrup of orange-flower water.

Liqueur dite de la Grande Chartreuse.

Green (Verte).

Dried lemon balm	500	grammes.
Hyssop in flower (dried tops)	250	"
Peppermint (dried)	250	"
Genepi	250	"
Balsamite (*balsamita major*)	125	"
Thyme	30	"
Angelica (seeds)	125	"
Angelica (roots)	62	"
Flowers of arnica	15	"
Buds of balsam poplar	15	"
China cinnamon	15	"
Mace	15	"
Alcohol, 85°	62	litres.

Digest 24 hours; distill and rectify to obtain 60 litres of good spirit; then add 25 kilogrammes of refined white sugar dissolved by heat, in 24 litres of water; mix the whole, and, if necessary, add enough water to make up 100 litres. Mellow, then color green with the blue and infusion of saffron or caramel, according to the tint desired; size, and after repose, filter.

If this liqueur is colored with melisse, hyssop, or any other plant, the color will in a short time be decomposed and form quite a deposit in the bottles (see *green color*, p. 414).

Liqueur dite de la Grande Chartreuse.

Yellow (Jaune).

Lemon balm	250	grammes.
Hyssop in flower (tops)	125	"
Genepi	125	"
Angelica (seed)	125	"
Angelica (root)	30	"
Arnica flowers	15	"
China cinnamon	15	"
Mace	15	"
Coriander	1	kilog., 500 grms.
Socotrine aloes	30	grammes.
Cardamom (small)	30	"
Cloves	15	"
Alcohol, 85°	42	litres.
Refined white sugar	25	kilogrammes.

Water, a sufficient quantity to make up one hectolitre of liqueur; follow the directions for the preceding, and impart a yellow color with saffron.

Liqueur dite de la Grande Chartreuse.

White (Blanche).

Lemon balm	250 grammes.
Genepi	125 "
Hyssop in flower (tops)	125 "
Angelica (seeds)	125 "
Angelica (root)	30 "
China cinnamon	125 "
Mace	30 "
Cloves	30 "
Nutmegs	15 "
Cardamom (small)	30 "
Calamus	30 "
Tonka beans	15 "
Alcohol, 85°	52 litres.
Best refined white sugar	37 kilog., 500 grms.

Water, a sufficient quantity to make 100 litres.

Process same as the last.

The three receipts which we have given above produce perfect imitations of the liqueurs manufactured by the monks of St. Bruno, at the Carthusian Monastery, near Grenoble. These liqueurs, on account of the large proportion of alcohol which enters into their composition, require age; the monks, therefore, do not offer them for sale until two or three years after they have been manufactured.

China-China.

Spirit of Ceylon cinnamon	3 litres.
" cloves	50 centilitres.
" nutmegs	50 "
Infusion of curaçoa	3 litres.
Alcohol, 85°	33 "
Refined sugar	50 kilogrammes.
Water	26 litres.

Dissolve the sugar by heat; after cooling, mix with the perfumed spirits and the infusion, and complete the 100 litres with water if necessary. Color a deep yellow with caramel and a little saffron coloring.

Eau de la Chine.

China cinnamon	250 grammes.
Cloves	250 "
Nutmegs	60 "
Storax	125 "
Star anise	250 "
Sweet bay	125 "
Imperial tea	250 "
Alcohol, 85°	38 litres.

Digest, distill, and rectify as described above to draw off 36 litres; then dissolve 56 kilogrammes of very white refined sugar in water by the aid of heat, and, if necessary, make up the measure to 100 litres by the addition of water.

Eau de la Côte-Saint-André.

Spirit of Ceylon cinnamon	20 litres.
" cloves	1 litre.
Alcohol, 85°	15 litres.
Best refined white sugar	56 kilogrammes.
Water	26 litres.

Mix the perfumed spirits and alcohol; dissolve the sugar by heat in the water, and if necessary add enough water to make a hectolitre of liqueur.

Cinnamomum and *Crème de Cannelle* are made by the same receipt, and are nothing but eau de la Côte-Saint-André.

Eau de la Côte-Aux-Noyaux.

Spirit of Ceylon cinnamon	10 litres.
" cloves	1 litre.
" apricot seed	15 litres.
Alcohol, 85°	10 "
Best refined white sugar	56 kilogrammes.
Water	26 litres.

Proceed as above to make 100 litres.

Les eaux de la côte at one time enjoyed quite a reputation; the best were prepared by the Visitandines. They are still highly esteemed. They are sold in white glass bottles of a peculiar shape.

Curaçoa (Old Receipt).

Curaçoa rinds (Dutch) . . .	5 kilogrammes.
Rind of fresh oranges, number	80.
Alcohol, 85°	54 litres.

Steep the curaçoa rinds in *cold* water, and when they are soft enough, strip off the outer skin and digest it with the orange peel; distill and rectify to draw off 36 litres of good spirit; add 56 kilogrammes of best refined white sugar dissolved by heat in 22 litres of water; when cold, mix the whole together, and add 4 litres of alcohol coloring, 30 centilitres of the infusion of curaçoa, and enough water to make 100 litres of liqueur. Mellow, size, and after a sufficient rest, filter.

Superfine curaçoa ought to have a decided yellow color. This tint is obtained by adding a few drops of a solution of tartaric acid. The same effect is produced by the coloring prepared by the boiling process, or by extract of logwood; but in this case it will be necessary to add 4 litres of alcohol at 85°, to replace that contained in the alcoholic coloring.

The infusion of curaçoa is used to impart a slight bitterness of the orange to the liqueur; the quantity indicated may be increased or diminished according to the strength of the infusion or the taste of the maker.

We cannot too highly condemn the practice of using hot water for steeping the rinds of the curaçoa oranges, by which they lose a portion of their perfume, and acquire a rancid flavor which injures the liqueur considerably.

Frequently curaçoa, although quite transparent when looked through horizontally in a small glass, appears to be turbid when looked at from above; this effect is due to an excess of coloring, and is demanded by some persons.

Superfine curaçoa is sometimes taken mixed with water, when it acquires a rose tint. The change of color astonishes and charms the public, who erroneously regard it as a proof of excellence.

By following our receipts closely, a most satisfactory result will be obtained; that is to say, a curaçoa which will sustain a comparison with those of the best liquorists.

Curaçoa Blanc.

Spirit of curaçoa (fine) . . .	. 25 litres.
" oranges	. 12 "
Amertume (bitter tincture of curaçoa)	. 1 litre.
White sugar	. 56 kilogrammes.

Size, and after rest, filter.

We should observe that it is always allowable for the manufacturer to increase or diminish the quantity of sugar according to the taste of his peculiar locality; in Paris at the present time the preference is for strongly spirituous liqueurs that are not very sweet.

The *curaçoa blanc* may be prepared by the receipt for curaçoa; only replacing the alcoholic coloring by the same quantity of strong spirit.

Curaçoa Surfin.

Commencement of the operation.

Genuine rinds	. 25 kilogrammes.
Alcohol, 85°	. 50 litres.

1. After having stripped off the outer portion of the 25 kilogrammes of curaçoa rinds, and allowed them to digest for some days in the spirit, the liquid portion is poured off and distilled until 39 litres of a good article are drawn off; the rinds (*zestes*) are left in the digester (barrel or other vessel), care being taken to distill only the liquid.

2. When the 39 litres of good spirit have been drawn off by rectification, the spirit is poured on the rinds for a new maceration of twelve hours; then decant to make what is called *amertume* (or *bitter tincture of curaçoa*), which is set aside in a demijohn or other suitable vessel.

3. Then to the above-mentioned rinds (which have already served for two macerations) add for distillation—

Rinds of fresh oranges . .	. 6 kilogs., 250 grms.
Dry ribbons of curaçoa . .	. 3 " 125 "

Then add 75 litres of alcohol at 85°, and distill so as to obtain 75 litres of a good article, perfectly rectified.

The Manufacture of 104 *Litres of Curaçoa.*

Perfumed spirits of curaçoa .	14 litres.
Spirit of the dried ribbons of curaçoa	10 "
Amertume	6 litres, 25 centilitres.
Spirit of oranges . . .	6 " 25 "
Coloring	4 or 5 litres.
White sugar. . . .	56 kilogrammes.

Size with milk, one litre to the hectolitre.

In order to facilitate the operation, we append the receipts for preparing the spirits of dried ribbons of curaçoa and of oranges.

Spirit of Dried Ribbons of Curaçoa.

Dried ribbons of curaçoa . .	9 kilogrammes.
Alcohol, 85°	50 litres.

Make one or two distillations, according to the size of the apparatus, if the distillation is made in two operations, add to each, 20 litres of water, or 40 litres for the whole; rectify to obtain fifty litres of good spirit.

Spirit of Oranges.

Fresh oranges	8 kilogrammes.
Alcohol, 85°	31 litres.
Water for the distillation . .	30 "
Product	30 "

Rectify and distill slowly. The coloring should be prepared as follows: take a barrel having a double bottom, pierced with holes, and fixed about 10 centimeters from the head; fill it with logwood, arranged in layers, to which should be added a certain quantity of bicarbonate of soda, but which should not exceed 50 grammes to a barrel of 50 or 60 litres; add, also, 30 grammes of tartaric acid; cover the wood with superfine perfumed spirit, which will, in turn, be added to the manufacture.

Eau Divine.

Spirit of lemon	8 litres.
" oranges	6 "
" coriander	3 "
" nutmegs	3 "
Orange-flower water	1 litre.
Alcohol, 85°	18 litres.
Best refined white sugar	56 kilogrammes.

Add water enough to make 100 litres of liqueur, and proceed in the usual way.

Eau-de-Vie d'Andaye.

Aniseed	375 grammes.
Coriander	750 "
Bitter almonds	750 "
Angelica root	500 "
Cardamom, large	30 "
Cardamom, small	30 "
Fresh lemons (outer rind)	10 in number.
Alcohol, 85°	38 litres.

Digest, distill, and rectify to obtain 36 litres of perfumed spirit; then add—

Best refined white sugar	56 kilogrammes,
Infusion of orris-root	20 centilitres,

and enough water to make up one hectolitre of liqueur.

Conduct the operation as described above.

A more highly spirituous eau de vie d'Andaye than the above is prepared by using the same doses of perfume, omitting one-half of the sugar, and increasing the quantity of alcohol one-third (28 kilogrammes of sugar, and 54 litres of alcohol).

Eau-de-Vie de Dantzick.

Spirit of Ceylon cinnamon	3 litres, 50 centilitres.
" China cinnamon	6 " 50 "
" coriander	6 "
" cardamom, large	75 centilitres.
" cardamom, small	75 "
" muskmallow	50 "
Alcohol, 85°	18 litres.
Best refined white sugar	56 kilogrammes.

Water, a sufficient quantity to make one hectolitre of liqueur.

Operation as described.

It is usual to put fragments of gold or silver leaf into the white glass bottles containing eau de Dantzic.

This spirit as prepared in the city from which it takes its name, is more spirituous than that for which we have given the receipt, but it is not so agreeable.

Fenouillette de l'Ile de Rhé.

Spirit of fennel	16 litres.
" coriander . . .	2 "
Cinnamon water (China) . .	2 "
Alcohol, 85°	18 "
Best refined white sugar . .	56 kilogrammes.

Water, a sufficient quantity to make one hectolitre of liqueur.

Process as described above.

Crème de Fleurs d' Oranger.

Spirit of orange-flowers . . .	18 litres.
Alcohol, 85°	18 "
Best refined white sugar . .	56 kilogrammes.
Water	26 litres.

Proceed as above.

Crème de Framboises.

Spirit of raspberries	26 litres.
Alcohol, 85°	10 "

Sugar and water, as the last.

Proceed as usual, and color red with cochineal.

Huile de Kirschenwasser.

Fine kirsch, 50°	25 litres.
Spirit of apricot seeds . . .	5 "
Orange-flower water . . .	1 litre.
Alcohol, 85°	16 litres.
Best refined white sugar . .	50 kilogrammes.
Water	19 litres.

Proceed as described above.

Elixir de Garus.

Saffron	60 grammes.
Socotrine aloes	125 "
Myrrh	125 "
China cinnamon	125 "
Cloves	60 "
Nutmegs	60 "
Alcohol, 85°	36 litres.

Infuse for 24 hours; distill with care but without rectifying, to draw off 36 litres of perfumed spirit; add 56 kilogrammes of refined white sugar dissolved by heat in the requisite quantity of water; pour the boiling syrup on one kilogramme of capillaire of Canada (sweet fern); when cold, pass through a hair sieve, and proceed to mix the liquids to make one hectolitre of liqueur; then color yellow with saffron and caramel.

Crème de Génépi des Alpes.

Génépi in flower	2 kilogrammes.
Peppermint in flower	1 kilogramme.
Balsam	1 "
Angelica root	500 grammes.
Galanga	125 "
Alcohol, 85°	42 litres.

Macerate for 24 hours; distill and rectify to obtain 40 litres of good spirit; then add 37 kilogrammes, 500 grammes of white sugar, dissolved by heat, in 35 litres of water, and, if necessary, complete the hectolitre of liqueur by the addition of water. Mellow, then color a bright green with blue coloring and the infusion of saffron; size, and after rest, filter.

Mayorque.

Fresh oranges (outer rind), number	200.
Alcohol, 85°	54 litres.

Macerate 48 hours; distill and rectify to obtain 36 litres of good spirit; add 56 kilogrammes of refined white sugar, dissolved by heat, in 18 litres of water; when cold, mix the whole together, adding the juice of 200 oranges and 30 centilitres of the infusion of curaçoa. Color a golden yellow with caramel.

The name of this liqueur has reference to the country which produces the best oranges; it was invented at Orleans, and has a reputation even in the centre of

France; it is the same, even to the juice of the oranges, as the *gouttes* or *larmes de Malte.*

The liqueur called *acidule* or *aciduline*, which is made at Lyons, resembles the Mayorque in all essential particulars.

Crème de Menthe.

Spirit of peppermint . . .	30 litres.
Essence of peppermint (*English*)	15 grammes.
Alcohol, 85°	54 litres.
Best refined white sugar .	56 kilogrammes.
Water, a sufficient quantity.	

Dissolve the essence of mint in a little of the unperfumed alco hol, and proceed as described above.

The use of this essence is indispensable, if it is dedesired to obtain a liqueur which shall impart to the mouth the cool sensation produced by mint lozenges.

The hunter's cordial, or *eau de chasseur*, is nothing but crème de menthe, to which have been added some muskmallow and coriander.

Liqueurs du Mézenc.

Daucus of Crete	500 grammes.
Nutmegs	125 "
Mace	60 "
Muskmallow	60 "
Myrobolans	60 "
Roman chamomile . . .	2 kilogrammes.
Alcohol, 85°	38 litres.
Spirit of coriander . . .	50 centilitres.

Digest 24 hours; distill and rectify to obtain 36 litres of good spirit; add 56 kilogrammes of refined white sugar, dissolved by the aid of heat, in 22 litres of water; when cold, mix the whole together, and add 4 litres of the infusion of vanilla; then color a golden yellow with the curaçoa coloring prepared by boiling (see page 413).

This receipt gives a perfect imitation of the *liqueur du Mézenc* prepared at Lyons; it has the property, like it, of acquiring a rose tint when water is poured into it.

According to the declaration of the inventor of this liqueur, its perfume is prepared from plants of the mountain of Mézenc (Switzerland).

Crème de Mille-Fleurs.

Spirit of orange flowers	8 litres.
" roses	9 "
" muskmallow	50 centilitres.
" sassafras	2 litres, 50 centilitres.
Alcohol, 85°	16 "
Best refined white sugar	56 kilogrammes.

Water, a sufficient quantity to make one hectolitre.

Process as directed above.

Crème de Moka.

Spirit of Moka	30 litres.
Alcohol, 85°	6 "
Best refined white sugar	56 kilogrammes.

Water, a sufficient quantity to make one hectolitre.

Process as above.

Crème de Noisette à la Rose.

Spirit of bitter almonds	10 litres.
" roses	10 "
Alcohol, 85°	16 "
Refined white sugar	56 kilogrammes.
Water	26 litres.

Product, 100 litres of liqueur.

Process as described. If required, impart a rose color with cochineal.

Crème de Noyaux.

Spirit of apricot seeds	26 litres.
" bitter almonds	10 "
Orange-flower water	1 litre.
Best refined white sugar	56 kilogrammes.
Water	25 litres.

Product, 100 litres.

Process as described.

Crème de Noyaux de Phalsbourg.

Spirit of apricot seeds	26 litres.
" bitter almonds	7 "
" oranges	1 litre.
" lemons	1 "
" China cinnamon	50 centilitres.
" cloves	25 "
" nutmegs	25 "
Orange-flower water	1 litre.
Best refined white sugar	56 kilogrammes.
Water	25 litres.

Product, 100 litres.

The analysis of one litre of eau de noyaux de Phalsbourg from the house of Hoffman-Forty, which enjoys a well-merited reputation, gives the following result:—

Alcohol, 85°	32 centilitres.
Sugar	375 grammes.
Water	43 centilitres.

The saccharometer, plunged into the liqueur, marks 14 degrees.

Crème d'Œillets.

Spirit of violets	25 litres.
" cloves	2 "
Alcohol, 85°	9 "
Refined white sugar	56 "
Water	26 "

Color red with cochineal. Product, 100 litres.

Eau d'Or.

Spirit of lemons	10 litres.
" oranges	8 "
" coriander	4 "
" daucus	2 "
" fennel	2 "
Orange-flower water	1 litre.
Alcohol, 85°	10 litres.
Refined white sugar	56 kilogrammes.
Water	25 litres.

Color yellow with saffron. Proceed as above. Product, 100 litres.

This liqueur, the name of which has allusion to the potable gold of the alchemists, is very ancient. It was at one time looked on as a sort of panacea.

The *eau d'argent* is prepared in the same way, the color being omitted.

These liqueurs are sold in white glass bottles, in which are placed a few fragments of gold leaf in the first, and of silver leaf in the second.

Parfait-Amour de Lorraine.

Spirit of lemons	4 litres.
" oranges	4 "
" coriander	5 "
" anise	3 "
Alcohol, 85°	20 "
Sugar and water, the usual quantity.	

Color red with cochineal. Product, 100 litres.

Persico.

Spirit of bitter almonds . .	15 litres.
" dill (*anethum*) . .	2 "
" China cinnamon . .	2 "
" coriander . . .	2 "
" fennel	1 litre.
Orange-flower water . . .	1 "
Alcohol, 85°	14 litres.
Best refined white sugar . .	56 kilogrammes.
Water	25 litres.

Product, 100 litres.

Raspail's Liqueur Hygienique et de Dessert.

Angelica (dried tops) . .	1 kilog., 650 grms.
Angelica (dried roots) . .	1 "
Calamus	440 grammes.
Myrrh	250 "
Cinnamon	250 "
Socotrine aloes	125 "
Cloves	100 "
Nutmegs	30 "
Saffron	10 "
Alcohol, 85°	30 litres.

Macerate 24 hours, distill carefully, but without rectifying, to draw off 30 litres of spirit; add 37 kilogrammes, 500

grammes only of refined white sugar, dissolved by heat in 40 litres of water; when cold, mix, adding five litres of the infusion of vanilla. Product, 100 litres of liqueur. Mellow, and then color yellow with the infusion of saffron and caramel; size, and, after sufficient rest, filter.

This receipt, which is not exactly the same as that furnished by Raspail,* since it is prepared by distillation, and contains no camphor, yields an excellent liqueur, which will bear comparison with any liqueur whatsoever which may be sold under the name of *Raspail.*

Huile de Rhum.

Fine rum, 50°	30 litres.
Alcohol, 85°	18 "
Refined white sugar	50 kilogrammes.
Water	18 litres.

Color a deep yellow with caramel. Product, 100 litres.

Crème de Roses.

Spirit of roses	30 litres.
Alcohol, 85°	6 "
Refined white sugar	56 kilogrammes.
Water	26 litres.

Color red with cochineal. Product, 100 litres.

The *crème de roses musquée* is prepared by the same receipt, with the addition of some drops of tincture of musk.

Eau des Sept-Graines.

Spirit of dill	3 litres.	
" angelica (seed)	3 "	50 centilitres.
" anise	3 "	50 "
" celery	3 "	50 "
" chervi	2 "	
" coriander	3 "	50 "
" fennel	3 "	
Alcohol, 85°	15 "	
Refined white sugar	56 kilogrammes.	
Water	26 litres.	

Color yellow with caramel. Product, 100 litres.

* The genuine receipt will be given hereafter.

Scubac de Lorraine.

Spirit of saffron	2 litres.
" cinnamon . . .	5 "
" cloves	4 "
" nutmegs	3 "
Orange-flower water . . .	1 litre.
Alcohol, 85°	22 litres.
Refined white sugar . . .	56 kilogrammes.
Water	25 litres.

Color a deep yellow with saffron and caramel. Product, 100 litres. Process same as above.

Crème de Thé de la Chine.

Spirit of tea	35 litres.
" angelica roots . . .	1 litre.
Best refined white sugar . .	56 kilogrammes.
Water	26 litres.

Process as above. Product, 100 litres.

The *crème de thé* is put up in white glass flasks covered with silk printed with Chinese characters and scenes.

Huile de Vénus.

Spirit of daucus	4 litres.
" caraway	2 "
" chervi	2 "
" dill	4 "
" lemons	6 "
" oranges	4 "
Orange-flower water . . .	1 litre.
Alcohol, 85°	14 litres.
Refined white sugar . . .	56 kilogrammes.
Water	25 litres.

Color a bright yellow with saffron. Product, 100 litres.

Eau Verte de Marseille.

Spirit of cinnamon . . .	6 litres.
" coriander . . .	4 "
" caraway . . .	4 "
" peppermint . . .	4 "
" lemons	10 "
" oranges	8 "
Refined white sugar . . .	56 kilogrammes.
Water	26 litres.

Color grass-green with saffron and blue. Product, 100 litres.

Vespétro de Montpellier.

Spirit of muskmallow . . .	1 litre.
" dill	3 litres.
" anise	4 "
" caraway	6 "
" coriander	6 "
" daucus (candy carrot) .	3 "
" fennel	3 "
Alcohol, 85°	10 "
Best refined white sugar . .	56 kilogrammes.
Water	26 litres.

If required, give a bright yellow with the infusion of saffron.

Proceed as above. Product, 100 litres.

Eau Virginale ou de Pucelle.

Spirit of celery	10 litres.
" juniper	4 "
" candy carrot (*daucus*) .	4 "
" China cinnamon . .	2 "
" cloves	1 litre.
Orange-flower water . . .	1 "
Rose water	1 "
Alcohol, 85°	15 litres.
Best refined white sugar . .	56 kilogrammes.
Water	24 litres.

Process as above. Product, 100 litres.

West Indian Liqueurs (Liqueurs Surfines des Iles).

West Indian liqueurs for more than a century have enjoyed an extraordinary reputation, due to their fragrance, delicacy of flavor, and richness. For a long time it was thought that they owed their superiority to the *cane spirit* (*tafia*) used in their preparation; but common sense has exploded this prejudice. It has been ascertained that *cane spirit* (or rum) imparts an empyreumatic flavor to liqueurs; besides, the liquorists of the Indies now compound their liqueurs with the *trois-six* of France.

The greater part of the Indian liqueurs which are imported from Martinique, Guadaloupe, and Barbadoes are prepared from aromatics collected from vegetables indigenous to those countries—as the bark of the liriodendron (tulip-tree), the allspice, Jamaica balsam, which has the odor of the rose, the narrow-leaved myrtle with odor of the pippin, and a number of other ingredients which, although but little known, are highly prized on account of their fragrance.

The widow of *Amphoux-Chassevent* (Madeline Achard), born at Marseilles in 1707, who settled in Martinique in 1769, where she died in 1812, had a world-wide reputation for these liqueurs. They were known as *liqueurs de la veuve Amphoux*. At the present time, those of *Grand Maison* of Fort Royal enjoy as great a reputation.

The West Indian liqueurs are prepared in the same way as the superfine French liqueurs; the proportions of alcohol and sugar are invariable, to wit, 40 litres of rectified perfumed spirit, and 56 kilogrammes of sugar.

To avoid constant repetition, it is to be understood that all the receipts for these liqueurs apply to the manufacture of 100 litres; that the sugar, for reasons already given, should always be dissolved by the aid of heat, and suffered to cool before using; that, after the mixture is made, the liqueur should be *mellowed* (tranchée), colored, sized, and, finally, after a rest of some days, filtered.

Baume Divin.

Balsam of Peru	125 grammes.
" Tolu	125 "
Socotrine aloes	30 "
Muskmallow	125 "
Rose wood	250 "
Alcohol, 85°	42 litres.

Digest for 24 hours; distill and rectify to draw off 40 litres of perfumed spirit; then add—

Rose water	3 litres.
Cinnamon water	2 "
Best refined white sugar . .	56 kilogrammes.
Water	17 litres.

Baume Humain.

Balsam of Peru	250 grammes.
Benzoin (tears)	125 "
Myrrh	60 "
Alcohol, 85°	42 litres.

Digest 24 hours; distill and rectify to draw off 40 litres of perfumed spirit, and add—

Orange-flower water . . .	1 litre.
Rose water	1 "
Best white sugar	56 kilogrammes.
Water	20 litres.

Crème d'Ananas.

Bananas (fresh plucked) . . .	8 kilogrammes.
Alcohol, 85°	40 litres.

Crush the bananas and infuse them in the alcohol for eight days; pass the liqueur through a silk strainer; dissolve 56 litres of sugar in 27 litres of water, and pour it into the liqueur with 50 centilitres of the infusion of vanilla; color a bright yellow with caramel.

Bananas, being always high priced, are frequently replaced by other fruit; the following is a receipt for an imitation :—

Very ripe sickle pears . . .	10 kilogrammes.
Spirit of raspberries . . .	10 litres.
Infusion of vanilla	2 "
Alcohol, 85°	28 "

Proceed as above.

Crème des Barbabes.

Fresh cedrats (outer rind), number	100.
Fresh oranges (outer rinds), number	50.
Alcohol, 85°	50 litres.

Digest 24 hours; distill and rectify to draw off 40 litres, and add—

Cinnamon water	50 centilitres.
Water of cloves	25 "
Water of mace	25 "
Best white sugar	56 kilogrammes.
Water	21 litres.

Crème de Cachou.

Catechu (*terra japonica*)	3 kilogrammes.
Alcohol, 85°	42 litres.

Digest 24 hours; distill and rectify to obtain 40 litres of perfumed spirit, then add—

Orange-flower water	2 litres.
Best white sugar	56 kilogrammes.
Water	20 litres.

Crème de Moka.

Mocha coffee	5 kilogrammes.
Bitter almonds	1 kilogramme.
Alcohol, 85°	42 litres.

Roast the coffee; then reduce it to a coarse powder; digest, distill, and rectify to draw off 40 litres of good spirit, to which add—

Best white sugar	56 kilogrammes.
Water	22 litres.

Crème de Noyaux.

Apricot seeds (kernel)	6 kilogrammes.
Peach seeds (kernel)	2 "
Bitter almonds	2 "
Alcohol, 85°	40 litres.

Digest and distill (without rectifying) to obtain 40 litres of perfumed spirit; then add—

Orange-flower water	2 litres.
Best white sugar	56 kilogrammes.
Water	20 litres.

The *crème de noyaux rouge* is prepared in the same way, only using a sugar of inferior whiteness, and is colored with cochineal.

Crème Sapotille de la Martinique.

Storax	250 grammes.
Muskmallow	60 "
Yellow sanders (*santalum citrinum*)	250 "
Alcohol, 85°	42 "

Proceed as for *crème de Moka,* and draw off 40 litres of good spirit; then add—

Orange-flower water . . .	1 litre.
Rose water	1 "
Best white sugar	56 kilogrammes.
Water	20 litres.

Huile de Badiane.

Star anise (*badiane*) . . .	2 kilogrammes.
Rosewood	500 grammes.
Cascarilla wood	500 "
Alcohol, 85°	42 litres.

Proceed as above to draw off 40 litres of perfumed spirit, and add—

Best white sugar	56 kilogrammes.
Water	22 litres.

The *huile d'anis des Indes blanche* and *rouge* are prepared in the same manner; for the latter a colored sugar is used and it is colored with cochineal.

Huile de Cacao.

Caracas cocoa	2 kilog., 250 grms.
West Indian cocoa . . .	2 " 250 "
Alcohol, 85°	43 litres.

Roast the cocoa and reduce it to a powder; digest for three days; distill and rectify to obtain 40 litres of good spirit, and add—

Best white sugar	56 kilogrammes.
Water	22 litres.

Infusion of vanilla, according to taste.

Huile de Cédrats.

Fresh cedrats (outer rind), number	150.
Alcohol, 85°	50 litres.

Digest, distill, and rectify to obtain 40 litres of good spirit, to which add—

White sugar	56 kilogrammes.
Water	22 litres.

Color a bright yellow with caramel.

The *fine orange* and *huile de bergamotes* are prepared in the same way—substituting the cedrats by fresh oranges and bergamots. These two liqueurs are also colored a bright yellow.

Huile de Cannelle.

Ceylon cinnamon	750 grammes.
China cinnamon	250 "
Cloves	60 "
Alcohol, 85°	40 litres.

Digest and distill carefully (without rectifying) to obtain 40 litres of good spirit; then add—

White sugar	56 kilogrammes.
Water	22 litres.

Color golden yellow with caramel.

Huile des Créoles.

Muskmallow (ambrette)	500 grammes.
Nutmegs	125 "
Cloves	125 "
Alcohol, 85°	40 litres.

Digest 24 hours; distill carefully (without rectifying) to obtain 40 litres of perfumed spirit, and add—

White sugar	56 kilogrammes.
Water	22 litres.

Color red with cochineal.

Huile de Fernambouc is prepared by the same receipt, being colored a deep yellow with Brazil wood, to which are added a few drops of a solution of tartaric acid to redden the color.

Huile de Girofle.

Cloves bruised (*girofles*)	500 grammes.
China cinnamon	150 "
Alcohol, 85°	40 litres.

Proceed as in the last receipt, and add—

White sugar	56 kilogrammes.
Water	22 litres.

Color a deep yellow with caramel.

Huile de Rhum.

Rum (old and extra)	50 litres.
White sugar	50 kilogrammes.
Water	18 litres.

Dissolve the sugar in the water by the aid of heat in a water-bath; then withdraw the fire from the furnace; lute on the cap of the still without fixing the goose-neck; then pour in the rum through the orifice of the cap, and mix the whole well together; close hermetically; after cooling, color a deep yellow with caramel.

Huile de Vanille.

Vanilla	200 grammes.
Alcohol, 85°	40 litres.
Refined white sugar	56 kilogrammes.
Water	22 litres.

Cut the vanilla into small pieces; then bruise it in a mortar with a portion of the sugar (about 5 kilogrammes); pour the alcohol and syrup of sugar into a water-bath, and add the vanilla sugar; mix the whole well together; after luting on the cap, heat the still gently so as to digest properly without distilling; allow it to become cool on the furnace; color with cochineal; size, and, after a sufficient rest, filter.

This process produces an excellent liqueur.

Zinziber or Huile de Gingembre.

Ginger	1 kilogramme.
Galanga	200 grammes.
China cinnamon	100 "
Cloves	60 "
Nutmegs	30 "
Mace	15 "
Alcohol, 85°	40 litres.

Distill in the same manner as for *huile de cannelle*, and add—

Refined white sugar	56 kilogrammes.
Water	22 litres.

Color a golden yellow with caramel.

West Indian liqueurs are put up for sale in bottles of dark grass-green of a peculiar shape; they are called *English bottles.*

Foreign Liqueurs.

"No man is a prophet in his own country," says a very ancient proverb. This saying is especially applicable to liqueurs; for if there is any country where the manufacture is conducted with intelligence, with taste, perfectly, it is manifestly in France, and particularly in Paris; yet, in spite of the superior quality of our productions, liquorists are most generally under the very unpleasant necessity of presenting their liqueurs to consumers as the product of foreign countries, in order that they may be considered as of superior quality; thus it often happens that we send liqueurs to foreigners which are sold as being manufactured in their own land.

This state of things is to be regretted. It has a tendency to maintain the reputation of foreign liqueurs in France, although Holland, Italy, Germany, &c., are far from being our rivals.

During our sojourn in Italy, we were convinced that French liqueurs were highly esteemed, and that for quality they were infinitely to be preferred to any that came under our notice, whether they came from Turin, Geneva, Florence, &c.

The proportions of liquids and other substances which enter into the composition of foreign liqueurs not being fixed, we shall indicate the quantities to be employed in each receipt, which will, however, be, as with all others, for one hectolitre of liqueur.

Anisette de Hollande.

Bitter almonds	1 kilogramme.
Anise	800 grammes.
Star anise	750 "
Coriander	250 "
Fennel	125 "
Imperial tea	190 "
Bay leaves	125 "
Balsam of Tolu	90 "
Muskmallow	60 "
Nutmegs	15 "
Alcohol, 85°	42 litres.

Macerate for 24 hours, distill and rectify to obtain 40 litres of perfumed spirit, and then add—

Rose water	2 litres.
Best white sugar	56 kilogrammes.
Water	20 litres.

Proceed and mix as described above and size.

The true *anisette de Hollande*, of the house of *Winand Fockink*, of Amsterdam, which we have analyzed, yields the following quantities for one litre of liqueur:—

Alcohol, 85°	40 centilitres.
Sugar	500 grammes.
Water	27 centilitres.

The saccharometer plunged into it marks 20 degrees.

Curaçoa de Hollande.

Rinds of curaçoa (Dutch) . .	5 kilogrammes.
Fresh oranges (outer rind) . .	80 (in number).
Alcohol, 85°	60 litres.

Proceed as for *curaçoa surfine*, and draw off 40 litres of perfumed spirit, to which add—

Infusion of curaçoa . . .	60 centilitres.
Alcohol color from Brazil wood .	4 litres.
Refined white sugar . . .	50 kilogrammes.
Water	22 litres.

The analysis of the genuine Dutch curaçoa of the house of *Winand Fockink*, of Amsterdam, yields the following:—

Alcohol, 85°	47 litres.
Sugar	375 grammes.
Water	28 centilitres.

The saccharometer when plunged into this liquid stands at 10°. The large proportion of alcohol contained in the Dutch curaçoa explains why this instrument does not indicate a larger proportion of sugar.

Crème Genièvre de Hollande.

Old gin, 50°	60 litres.
Best white sugar	25 kilogrammes.
Water	23 litres.

Proceed as above.

Liqueur Flamande (60 litres).

Cloves	30 grammes.
Ceylon cinnamon	30 "
Angelica seed	60 "
Star anise	60 "
Coriander	100 "
Rinds of four oranges.	
Alcohol, 85°	26 litres.
Raw sugar	40 "

Pulverize the solid substances, and digest in the alcohol for eight days; dissolve the sugar, and pour it, boiling hot, on the aromatics; size and filter; add enough water to make the quantity up to 60 litres.

Dutch Bitters (*Bitter de Hollande*).

Dutch curaçoa rinds	1 kilogramme.
Calamus	250 grammes.
Socotrine aloes	250 "
Brazil wood	2 kilogrammes.
Alcohol, 85°	60 litres.
Water	40 "

Place the solid substances in a water-bath with the alcohol and water; infuse them at a gentle heat for 24 hours; when cold, add 15 grammes of alum, and filter without sizing.

Amer de Hollande (*Dutch Bitters*).

Rinds of Dutch curaçoa	1 kilogramme.
Fresh lemons (outer rind), number	20.
Fresh oranges (outer rind), "	20.
Alcohol, 50°	100 litres.

Digest one month; draw off the clear liquid and filter.

The Dutch liqueurs are put up in square or round reddish-gray stone jugs; also in black glass bottles with a long neck or compressed sides; the latter are called *marteaux*.

Véritable Eau de Vie de Dantzick.

Ceylon cinnamon	250 grammes.
Cloves	15 "
Celery seeds	125 "
Caraway seeds	125 "
Anise seeds	125 "
Cumin seeds	30 "
Alcohol, 85°	50 litres.

Digest for 24 hours, and distill with care (without rectifying) to draw off 50 litres of perfumed spirit, and add—

Best refined white sugar	25 kilogrammes.
Water	33 litres.

Finish the operation according to the usual methods, and add a sheet of broken gold leaf to each flask.

This liqueur being highly spirituous, and not very sweet, requires age. That which we have described under the French superfine liqueurs is generally preferred.

Franzoesisch Wasser de Dantzick.

Anise	500 grammes.
Star anise	500 "
Fennel	125 "
Coriander	250 "
Dry sage	500 "
Dry peppermint	500 "
Melisse	500 "
Alcohol, 85°	40 litres.

Digest for 24 hours; distill and rectify to draw off 38 litres of perfumed spirit, to which add—

Spirit of lemons	1 litre.
" orange	1 "
Refined white sugar	37 kilog., 500 grms.
Water	35 litres.

Color a brilliant red with cochineal, and proceed as usual.

Deutschland Wasser de Breslau.

Angelica roots	1 kilogramme.
Seeds of dill	125 grammes.
" caraway . . .	60 "
" cumin	30 "
Calamus	125 "
Chamomile	500 "
Nutmegs	30 "
Alcohol, 85°	42 litres.

Digest 24 hours; distill and rectify to draw off 40 litres of good spirit, and add—

Infusion of orris-root . . .	50 centilitres.
Refined white sugar . . .	37 kilog., 500 grms.
Water	35 litres.

Color a bright green with saffron and blue. Process as described above.

Persicot du Palatinat.

Peach kernels	6 kilogrammes.
Bitter almonds	2 "
Alcohol, 85°	36 litres.

Macerate 48 hours, and distill carefully to draw off 36 litres of perfumed spirit, and add—

Cinnamon water	75 centilitres.
Water of cloves	25 "
Orange-flower water . . .	1 litre.
Refined white sugar . . .	50 kilogrammes.
Water	24 litres.

Process as described.

Usquebaugh d'Ecosse (*Scotch*).

Saffron	60 grammes.
Juniper berries	250 "
Star anise	125 "
Angelica root	125 "
Coriander	250 "
China cinnamon	60 "
Muskmallow	60 "
Fresh lemons (outer rind), number .	25.
Alcohol, 85°	40 litres.

Digest one month, stirring from time to time; then strain through a hair sieve, and add—

Orange-flower water	2 litres.
Refined white sugar	25 kilogrammes.
Water	41 litres.

Communicate a light reddish-yellow tint with cochineal.

Usquebaugh is a drink of high repute in Great Britain; Sir Walter Scott frequently refers to it in his novels, and Paul Fèval makes mention of it in his "*Mysteries of London.*" This liqueur was originally prepared at Batavia, and was introduced into Europe by the Dutch.

English Bitters.

Fresh lemons (outer rind), number	25.
Fresh oranges " "	25.
Calamus	125 grammes.
Ginger	60 "
Gentian	500 "
Elecampane (root)	120 "
China cinnamon	30 "
Cloves	15 "
Nutmegs	15 "
Alcohol, 85°	100 litres.

Macerate one month, stirring occasionally; pass through a hair sieve and filter without sizing.

Alkermes de Florence.

Muskmallow	150 grammes.
Calamus	150 "
Ceylon cinnamon	250 "
Cloves	60 "
Mace	60 "
Alcohol, 85°	40 litres.

Macerate for 48 hours; distill carefully in a water-bath (without rectifying) to draw off 40 litres of perfumed spirit, and add—

Extract of jasmin	30 grammes.
Infusion of orris-root	50 centilitres.
Rose water	6 litres.
Refined white sugar	56 kilogrammes.
Water	16 litres.

Proceed as with other liqueurs, and color a deep red with cochineal.

Aqua Bianca de Turin.

Ceylon cinnamon	500 grammes.
Cloves	60 "
Nutmegs	60 "
Alcohol, 85°	40 litres.

Digest for 24 hours, and distill (without rectifying) to obtain 40 litres of good spirit, and add—

Best white sugar	56 kilogrammes.
Water	22 litres.

Process as described. Place a sheet of broken silver leaf in each flask.

Aqua d' Oro de Turin.

Ceylon cinnamon	250 grammes.
Cloves	30 "
Angelica root	125 "
Daucus (candy carrot) . . .	125 "
Fresh lemons (outer rind), number .	80.
Alcohol, 85°	40 litres.

Digest 24 hours; distill in a water-bath (without rectifying) to draw off 40 litres of good spirit, and add—

Best refined white sugar . .	56 kilogrammes.
Water	22 litres.

Process as described. Place in each flask some fragments of gold leaf.

Cedrato di Palermo.

Fresh cedrats (outer rind) . .	200 (in number).
Alcohol, 85°	50 litres.

Distill, and rectify to obtain 40 litres of good spirit, and add—

Cinnamon water (Ceylon) . .	50 centilitres.
Water of cloves	25 "
Water of mace	25 "
Spirit of muskmallow . . .	50 "
Best refined white sugar . .	56 kilogrammes.
Water	21 litres.

Process as described above.

La Fioretto de Florence.

Larger cardamom	250 grammes.
Nutmegs	250 "
Alcohol, 85°	38 litres.

Distill, with care, in a water-bath, without rectifying, to draw off 38 litres of perfumed spirit, and add—

Infusion of orris-root . . .	2 litres.
Orange-flower water . . .	2 "
White sugar	56 kilogrammes.
Water	20 litres.

Proceed as above, coloring rose with cochineal.

La Giovane de Turin.

China cinnamon	125 grammes.
Benzoin in tears	30 "
Storax (best)	125 "
Nutmegs	60 "
Muskmallow	30 "
Bay leaves	250 "
Rosewood	250 "
Alcohol, 85°	40 litres.

Distill, with care, in a water-bath, without rectifying, to draw off 40 litres of spirit, and add—

Orange-flower water . . .	1 litre.
White sugar	56 kilogrammes.
Water	21 litres.

Color a bright red with cochineal, and proceed as described.

Liquore delle Alpi.

Larger absinthe (picked from stalks)	500 grammes.
Lesser absinthe (picked from stalks)	500 "
Angelica (tops)	500 "
Peppermint (picked from the stalks)	500 "
Hyssop in flower	500 "
Genepi	500 "
Anise	500 "
Fennel seeds	250 "
Lemons (outer rind) . . .	10 (in number).
Alcohol, 85°	38 litres.

Digest 24 hours; distill in a water-bath, and rectify to obtain 36 litres of perfumed spirit; add 56 kilogrammes of best white sugar, converted into syrup, with 30 litres of water, and proceed as usual.

Maraschino de Zara.*

Maraschino water	20 litres.
Orange-flower water . . .	1 litre.
Rose water	1 "
Alcohol, 85°	40 litres.
Best white sugar	56 kilogrammes.

Place the perfumed waters and sugar in the water-bath; put on the cap without attaching the goose-neck; lute and heat quickly, passing a stirring-stick through the opening in the cap, in order to stir the syrup; when the sugar is dissolved, add the alcohol; stir again, and close hermetically; draw the fire from the furnace, and allow the liqueur to cool in the still.

Maraschino is also prepared by the following receipt:—

Spirit of raspberries . . .	15 litres.
" apricot seeds . . .	8 "
" orange flowers . .	2 "
Old kirsch	20 "
Best white sugar	56 kilogrammes.
Water	17 litres.

Proceed as above.

Myrobolano, or Myrobolanti.

Myrobolans	500 grammes.
Storax, best	125 "
Bay laurel	500 "
Yellow sanders	250 "
Alcohol, 85°	42 litres.

Digest 24 hours, distill, and rectify to draw off 40 litres of good spirit, and add—

Rose water	2 litres.
Cinnamon water (China) . . .	25 centilitres.
Best white sugar	56 kilogrammes.
Water	20 litres.

Process as described before.

* From macarska or marasca cherry, a fruit growing in Dalmatia.

Olio di Cremona.

Fresh lemons (outer rinds)	50 (in number).
Fresh oranges "	40 "
Storax (best)	250 grammes.
Alcohol, 85°	42 litres.

Digest 24 hours, distill, and rectify to obtain 40 litres of spirit, and add—

Rose water	2 litres.
White sugar	56 kilogrammes.
Water	20 litres.

Color red with cochineal, and proceed as described.

Olio de Maccheroni di Genova.

Spirit of bitter almonds	10 litres.
" orange flowers	6 "
" roses	4 "
" cinnamon (China)	25 centilitres.
" nutmegs	25 "
Alcohol, 85°	15 litres, 50 centilitres.
White sugar	50 kilogrammes.
Water	30 litres.

Color a clear yellow with infusion of saffron, and proceed as above.

Rosolio di Menta di Pisa.

Peppermint in flower	6 kilogrammes.
Essence of peppermint	20 grammes.
Alcohol, 85°	38 litres.

Macerate the mint for 24 hours in the alcohol; distill and rectify to obtain 36 litres of spirit, in which dissolve the essential oil of mint; then add 50 kilogrammes of best white sugar, made into a syrup, with 30 litres of water. Process as usual.

Rosolio di Torino.

Bitter almonds	1 kilog., 500 grms.
Apricot seeds	2 kilogrammes.
Anise	500 grammes.
Coriander	125 "
Fennel	125 "
Alcohol, 85°	32 litres.

Digest 24 hours, distill and rectify to obtain 30 litres of perfumed spirit, and add—

Spirit of roses	10 litres.
Cinnamon water (China)	50 centilitres.
Water of cloves	25 "
" nutmegs	25 "
Orange-flower water	1 litre.
White sugar	56 kilogrammes.
Water	20 litres.

Impart a clear rose color with cochineal, and proceed as above.

Rubino di Venezia.

Bitter almonds	1 kilogramme.
Star anise	1 "
Fennel	125 grammes.
Storax (best)	125 "
Angelica (roots)	125 "
Alcohol, 85°	42 litres.

Digest 24 hours, distill and rectify to obtain 40 litres of good spirit, and add—

Infusion of vanilla	50 centilitres.
Cinnamon water (China)	50 "
Water of cloves	20 "
" " nutmegs	30 "
White sugar	56 kilogrammes.
Water	21 litres.

Impart a bright rose color with cochineal, and proceed as above. The Italian liqueurs are put up in white or clear green glass bottles of various forms. Most of these bottles are covered with a species of cord or twisted husks of Indian corn. There are some which have a certain air of originality which is quite peculiar, particularly those called *fiasco*.

Chiraz.

(A New Persian Liqueur.)

Muskmallow (ambrette)	188 grammes.
Anise	500 "
Dill	250 "
Caraway	500 "
Coriander	1 kilog., 500 grms.
Daucus	250 grammes.
Fennel	575 "
Sassafras (wood)	188 "
Angelica (root)	500 "
Florentine iris	125 "
Vanilla	60 "
Orange-flower water	2 litres.
Alcohol, 85°	35 "
White sugar	45 kilogrammes.
Water	33 litres.

Distill and rectify with care, and proceed according to principles already laid down.

Color a clear yellow with saffron.

Nomenclature and Receipts for Liqueurs by Infusion.

As we have said above, there are some aromatic substances from which it is impossible to extract the perfume by distillation with either water or alcohol. If it is desired to prepare liqueurs with these substances, the process by infusion becomes obligatory.

Almost all of the liqueurs prepared by infusion are designated by the name *ratafia.* According to certain authors, the word *ratafia* is the same as *ratafier* (to ratify), and is derived from two Latin words, *rata fiant* (that the affair agreed on shall be accomplished). This opinion is founded on a custom among the ancients when they had discussed public affairs at the table, by which they confirmed the resolutions taken by drinking at the close of the feast some pleasant liqueur; a remnant of this usage still remains in our day among a certain class of people.

The number of receipts for liqueurs by infusion is small enough to justify our giving under each the pro-

portions of aromatic substances as well as of the alcohol, sugar, and water that enter into their composition. We repeat, and more particularly with respect to ratafias, what we have already said in reference to the inequality of results. Although using with the most scrupulous attention the quantities which we indicate, it may happen that a liqueur prepared at one time will be far inferior to the same liqueur prepared at another; the condition of the materials or fruits, their state of maturity, the influence of temperature, a more or less prolonged infusion, &c. &c., are so many influences that may cause differences in liqueurs. Here our mission ends; we cannot communicate to our readers that skill and tact which enable a good liquorist to determine immediately, on tasting it, whether a liqueur is possessed of the requisite perfume; this experience is only acquired by long practice.

The receipts, like those which precede, all apply to one hectolitre of liqueur.

Ordinary Liqueurs (Liqueurs Ordinaires).

Huile de Vanille.

Infusion of vanilla	1 litre.
Tincture of storax	25 centilitres.
Alcohol, 85°	24 litres.
Sugar	12 kilogs., 500 grms.
Water	66 litres.

Color with archil.

Brou de Noix.

Infusion of walnut hulls (old)	21 litres.
Spirit of nutmegs	25 centilitres.
Alcohol, 85°	13 litres.
Sugar	12 kilog., 500 grms.
Water	57 litres.

Color a deep yellow with caramel. If the perfume of this liquid is not sufficiently decided, a few litres of the water of nuts may be added, omitting the same quantity of water.

Ratafia de Cassis.

Infusion of cassis (currants) (*première*)	25 litres.
Alcohol, 85°	12 "
Sugar	12 kilogs., 500 grms.
Water	54 litres.

If it is desired to employ the *second* (*deuxième*) infusion, the process is as follows:—

Infusion of cassis (*deuxième*)	32 litres.
Alcohol, 85°	6 "
Sugar	12 kilogs., 500 grms.
Water	54 litres.

The *third* infusion (*troisième*) may be used thus:—

Infusion of cassis (*troisième*)	45 litres.
Alcohol, 85°	7 "
Sugar	12 kilog., 500 grms.
Water	39 litres.

In the event that this last preparation is not sufficiently perfumed, two or three litres of the infusion of currant leaves may be added, withholding at the same time a corresponding quantity of alcohol, 85°.

The three examples given will serve as a guide in case all three, or only two, of the infusions are used simultaneously.

Cassis Ordinaire.

(100 litres.)

Pure alcohol	21 litres, 25 centil's.
Or	25 " 85°.
Infusion, first charge 50° (taken in the manufacturing)	18 "
Wine of Rousillon or Loire	7 "
Alcohol, 85°	14 "
Raw sugar (decolorized or well clarified)	12 kilog., 500 grms.
Water, to make up the quantity.	

Ratafia de Framboises.

Infusion of raspberries . .	15 litres.
" " currants or wild cherries	5 "
Alcohol, 85°	12 "
Sugar	12 kilog., 500 grms.
Water	59 litres.

The *first* infusion of currants, or wild cherries, serves to give this liqueur a higher color.

Ratafia de Coings (quinces).

Expressed juice of thoroughly ripe quinces	6 litres.
Spirit of cloves	50 centilitres.
Alcohol, 85°	25 litres.
Sugar	12 kilog., 500 grms.
Water	60 litres.

Give a bright yellow color with caramel. The ratafia of pears is prepared in the same way.

Liqueurs Doubles.

Huile de Vanille.

Infusion of vanilla	2 litres.
Alcohol, 85°	48 "
Sugar	25 kilogrammes.
Water	33 litres.

Color deep red with archil.

Brou de Noix.

Infusion of walnut hulls . .	42 litres.
Spirit of nutmegs	50 centilitres.
Alcohol, 85°	25 litres.
Sugar	25 kilogrammes.
Water	18 litres.

Give a strong yellow color with caramel, in order that when the liqueur is reduced the color may be sufficiently decided.

Ratafia de Cassis.

Infusion of currants (*première*)	50 litres.
Alcohol, 85°	24 "
Sugar	25 kilogrammes.
Water	10 litres.

Another.

Infusion of currants (*première*)	25 litres.
" (*deuxième*)	30 "
Alcohol, 85°	17 "
Sugar	25 kilogrammes.
Water	11 litres.

Ratafia de Framboises.

Infusion of raspberries	30 litres.
" currants or wild cherries	10 "
Alcohol, 85°	24 "
Sugar	25 kilogrammes.
Water	19 litres.

Liqueurs Demifines.

Huile de Vanille.

Infusion of vanilla	4 litres.
Alcohol, 85°	22 "
Sugar	25 kilogrammes.
Water	55 litres.

Color red with cudbear, and if a bright red is desired, add a little caramel.

Huile de Violettes.

Infusion of orris-root	6 litres.
Alcohol, 85°	22 "
Sugar	25 kilogrammes.
Water	55 litres.

Color violet with cudbear and blue.

Brou de Noix.

Infusion of walnut hulls (old)	25 litres.
Spirit of nutmegs	30 centilitres.
Alcohol, 85°	13 litres.
Sugar	25 kilogrammes.
Water	45 litres.

Color a dark yellow with caramel.

Ratafia de Cassis.

Infusion of currants (*première*)	30 litres.
" raspberries	5 "
Alcohol, 85°	12 "
Sugar	25 kilogrammes.
Water	36 litres.

The same observations are repeated for this as the preceding *cassis*.

Cassis Demifin.

(100 litres.)

Pure alcohol	23 litres.
Or	28 " at 85°.
Infusion (*première*)	23 litres.
Wine of Loire or Roussillon	8 "
Infusion of wild cherries	3 "
" raspberries	3 "
Alcohol, 85°	13 "
Decolorized raw sugar	25 kilogrammes.
Water, a sufficient quantity.	

Ratafia de Cerises.

Infusion of cherries	30 litres.
" wild cherries	5 "
Spirit of apricot seeds	5 "
Alcohol, 85°	4 "
Sugar	25 kilogrammes.
Water	39 litres.

The color ought not to be very dark.

Ratafia de Framboises.

Infusion of raspberries	20 litres.
" wild cherries	6 "
Alcohol, 85°	10 "
Sugar	25 kilogrammes.
Water	47 litres.

Ratafia de Quatre Fruits.

Infusion of currants, *première*	10 litres.
" cherries	10 "
" raspberries	8 "
" wild cherries	8 "
Alcohol, 85°	8 "
Sugar	25 kilogrammes.
Water	39 litres.

Ratafia de Coings.

Expressed juice of very ripe quinces	8 litres.
Spirit of cloves	50 centilitres.
Alcohol, 85°	28 litres.
Sugar	25 kilogrammes.
Water	47 litres.

Impart a bright yellow with caramel.

Liqueur Fines.

Huile de Vanille.

Infusion of vanilla	8 litres.
Alcohol, 85°	24 "
Refined white sugar	43 kilog., 750 grms.
Water	39 litres.

Color red with cudbear or cochineal.

Huile de Violettes.

Infusion of orris-root	10 litres.
Alcohol, 85°	22 "
Refined white sugar	43 kilogs., 750 grms.
Water	39 litres.

Color violet with cudbear and blue.

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Brou de Noix.

Infusion of walnut hulls (old)	. 30 litres.
Spirit of nutmegs . .	. 35 centilitres.
Alcohol, 85° . . .	. 15 litres.
Sugar	. 37 kilog., 500 grms.
Water	. 29 litres.

Color a deep yellow with caramel.

Ratafia de Cassis.

Infusion of currants, *première*	. 36 litres.
" raspberries .	. 8 "
Alcohol, 85° . . .	. 10 "
Sugar	. 37 kilog., 500 grms.
Water	. 21 litres.

Ratafia de Cerises.

Infusion of cherries . .	. 35 litres.
" wild cherries .	. 8 "
Spirit of apricot seeds .	. 6 "
Alcohol, 85° . . .	. 4 "
Sugar	. 37 kilog., 500 grms.
Water	. 21 litres.

Ratafia de Framboises.

Infusion of raspberries .	. 25 litres.
" wild cherries	. 10 "
Alcohol, 85° . . .	. 10 "
Sugar	. 37 kilogs., 500 grms.
Water	. 29 litres.

Ratafia de Quatre Fruits.

Infusion of currants, *première*	. 15 litres.
" cherries . .	. 10 "
" raspberries .	. 10 "
" wild cherries .	. 15 "
Alcohol, 85° . . .	. 4 "
Sugar	. 37 kilog., 500 grms.
Water	. 20 litres.

Ratafia de Coings.

Expressed juice of very ripe quinces	12 litres.
Spirit of cloves	75 centilitres.
Alcohol, 85°	30 litres.
Refined white sugar	37 kilog., 500 grms.
Water	32 litres.

Color a bright yellow with caramel.

Liqueurs Surfines.

Veritable Liqueur Hygiénique et de Dessert de Raspail.

Alcohol, 21° Cartier	1 litre.
Angelica root	30 grammes.
Calamus	2 "
Myrrh	2 "
Cinnamon	2 "
Aloes	1 gramme.
Cloves	1 "
Vanilla	1 "
Camphor	50 centigrammes.
Nutmegs	25 "
Saffron	5 "

"The whole is permitted to digest for several days in the sun, the bottle being kept well corked. It is then strained through a cloth of close texture; the bottle, again well corked, is to be kept in a quiet place."

M. Raspail says that "a liqueur may be prepared which will be quite as hygienic, as pleasant to drink, by adding to the ingredients above named 500 grammes of sugar, dissolved and caramelized in half a litre of water. If the liqueur is muddy, it should be passed through the cloth a second time, or the dose of brandy increased."

Finally, M. Raspail adds that "if it is desired to have it still more limpid, and more pleasant to drink, the liquid should be subjected to distillation, and the dose of aloes added to the distilled liqueur."

Although M. Raspail published his formula for the benefit of the public, he appears, by his frequent com-

plaints through the public prints, to be desirous of holding a monopoly in the manufacture. He especially objects to the use of his name on the labels of other manufacturers, because most of them do not use *all* the ingredients prescribed by him. It is allowable for us to remark that although there are some people who like camphor, there are others who do not like it (and we count ourselves among the number), and even if camphor does possess undoubted virtues as an external application, there is some room for discussion as to its value as an internal remedy. In his valuable *Manual de Parfumerie*, M. A. Debay remarks on this subject:—

"Extolled by M. V. Raspail, whose elixir had become popular, camphor was, for some years, in the public estimation, a panacea for all diseases. It was swallowed, smoked, chewed, and sprinkled on the beds of the sick. It was employed in ointments, liniments, and plasters; in fact, it was administered in every form; but, like every other matter of fashion, the fancy for camphor is daily passing away.

"The perfumer used camphor for perfuming his soaps, tooth-powders, and pastes—his sachets and other preparations.

"It was contended that the odor of camphor had the effect of driving away insects and preserving clothes and furs from the attack of moths.

"Experience has dissipated this notion, as well as its title to being a panacea."

For our part, we affirm that in the provinces, as well as in Paris, the liqueur of M. Combier, of Saumer, is preferred to that which contains camphor. The camphor masks all the ingredients of the formula except the angelica; we would therefore say, in agreement with M. Raspail, that the liqueur of M. Combier has no analogy with that invented by him.

The following is the receipt of M. Combier:—

Liqueur Hygiénique (de Saumur).

Angelica seed	450 grammes.
Calamus	950 "
Myrrh	450 "
Ceylon cinnamon	450 "
Aloes	300 "
Cloves	300 "
Cardamom (lesser)	300 "
Nutmegs	300 "
Outer rind of lemon . . .	2 kilogrammes.

Digest in 72 litres of alcohol, 85°; distill to draw off 50 litres of good spirit, taking care to separate the product in the distillation; set aside the remaining 22 litres to be used in another operation. Reduce the quantities in the receipt, if the liqueur is too highly perfumed.

Manufacture (100 litres).

Perfumed spirit as above . .	50 litres.
White sugar	25 kilogrammes.
Water, a sufficient quantity.	

Color a bright yellow with saffron; size, and after rest, filter.

Liqueur Stomachique Dorée.

Cinchona (red), bruised . .	187 grammes.
Dutch curaçoa (rind) . .	125 "
Ceylon cinnamon . . .	125 "
Vanilla	90 "
Saffron	10 "
Alcohol, 85°	36 litres.
Refined white sugar . .	37 kilogs., 500 grms.
Water	38 litres.

Digest 8 days, and strain off the liqueur with pressure; add the sugar and water; size and filter, and put some fragments of gold leaf in each bottle.

Crème de Vanille.

Infusion of vanilla . . .	10 litres.
Alcohol, 85°	26 "
Refined white sugar . . .	56 kilogrammes.
Water	26 litres.

Color red with cochineal.

Crème de Violette.

Infusion of orris-root	12 litres.
Alcohol, 85°	24 "
Refined white sugar	56 kilogrammes.
Water	26 litres.

Color violet with cochineal and blue.

Crème de Brou de Noix.

Infusion of walnut hulls (old)	40 litres.
Spirit of nutmegs	50 centilitres.
Alcohol, 85°	10 litres.
Refined white sugar	50 kilogrammes.
Water	16 litres.

Color a deep yellow with caramel.

Crème de Cassis.

Infusion of currants, *première*	42 litres.
Spirit of raspberries	5 "
Alcohol, 85°	6 "
Refined white sugar	50 kilogrammes.
Water	16 litres.

Ratafia de Cassis de Dijon.

Infusion of currants, *première*	25 litres.
" cherries	5 "
" wild cherries	5 "
" raspberries	5 "
Burgundy (or any other red wine of similar properties)	10 "
White sugar	50 kilogrammes.
Water	16 litres.

This is sometimes called *crème de vougeot.*

Crème de Cassis de Touraine.

(Superior to the Crème de Vougeot.)

Infusion of currants, *première*	26 litres.
" wild cherries	6 "
" raspberries	6 "
" cherries	6 "
Wine of Roussillon	9 "
Infusion of currant leaves	5 "
White sugar	50 kilogrammes.
Water	9 litres.

Dissolve the sugar in a water-bath with the 9 litres each of wine and water. After the liqueur is prepared, size; and, after a sufficient rest, bottle it without filtering.

Ratafia de Cerises de Grenoble.

Infusion of cherries . . .	25 litres.
" wild cherries . .	15 "
Spirit of apricot seeds . . .	6 "
" raspberries . . .	4 "
Refined white sugar . . .	50 kilogrammes.
Water	16 litres.

Ratafia de Grenoble, dit de Teyssère.

Currants	15 kilogrammes.
Raspberries	20 "
Cherries	20 "
Wild cherries	10 "
Alcohol, 85°	36 litres.
Refined white sugar . . .	50 kilogrammes.
Infusion of bay	50 centilitres.
Water of nuts	8 litres.
Infusion of galangal . . .	50 centilitres.

Crush the whole without breaking the seeds, and let it digest for one month, then strain with pressure, and add the sugar, previously dissolved by heat, in a sufficient quantity of water to make one hectolitre.

This liqueur is also prepared as follows:—

Take a sufficient quantity of wild cherries (very ripe) and (after removing the stems) crush them; then put them on the fire in a copper pan with a little water; heat rapidly, taking care to stir with a paddle until the liquid begins to thicken, then pour the whole on a sieve over a stone jar, and press the marc until it becomes cold; then prepare the ratafia as follows:—

Boiled wild-cherry juice . . .	10 litres.
Infusion of currants . . .	15 "
" cherries . . .	20 "
Spirit of raspberries . . .	10 "
Refined white sugar . . .	50 kilogrammes.

Dissolve the sugar by heat in the juice of the wild cherries, and, after cooling, complete the admixture, adding, if necessary, enough water to make one hectolitre.

Boiling does not affect the wild cherries, which have neither perfume nor parenchyma, the juice being highly aqueous; the action of the fire, on the contrary, is advantageous, because it develops a flavor as well as the saccharine principle.

The ratafia of Grenoble may also be prepared from the infusions of the fruits which enter into its composition.

The *ratafia de merises de Grenoble* is prepared as follows:—

Place 100 kilogrammes of thoroughly ripe cherries, separated from the stems and crushed, in a copper kettle, heat rapidly, stirring with a wooden spatula until the juice is very thick; at this point, pour the whole (marc and juice) into a hogshead, and, when cold, add 55 litres of white spirit at 59° (trois-six reduced); allow it to infuse for at least six weeks, then draw off the clear liquid and turn it into another hogshead to settle.

As may be observed, this ratafia contains no sugar except that derived from the fruit.

The *ratafias de Louvres* and *de Neuilly* are prepared in very nearly the same manner as the ratafia de Grenoble dit de Teyssère, only they have a more decided flavor of currants.

Ratafia de Framboises.

Infusion of raspberries	30 litres.
" wild cherries	10 "
Alcohol, 85°	10 "
Refined white sugar	50 kilogrammes.
Water	16 litres.

Guignolet d'Angers.

Infusion of cherries	20 litres.
" wild cherries	20 "
Alcohol, 85°	10 "
Sugar	50 kilogrammes.
Water	16 litres.

Receipts for Preparing Liqueurs by Volatile Oils or Essences without the use of the Still.

Liqueurs flavored by means of the direct solution of one or more volatile oils are never so pleasant nor so delicate as those prepared from distilled spirits. Although highly aromatic, these liqueurs are possessed of a harshness which connoisseurs recognize at once; they leave an enduring and oppressive sensation of heat and irritation in the mouth, throat, stomach, and sometimes even in the urinary organs of those who make use of them habitually.

Nevertheless, being fully aware of the fact that liqueurs prepared by solution are altogether inferior in every respect to those prepared by distillation, we are compelled to acknowledge that circumstances may exist which will oblige the liquorist to resort to the use of essences for the manufacture of liqueurs. Influenced by the probability of this necessity occurring with some of our readers, we shall describe the processes which we would recommend.

Common Liqueurs (Ordinaires).

As in the case of common liqueurs prepared by distillation or infusion, the proportions of sugar, alcohol, and water are invariable. The following will indicate the quantities of each which are required for the manufacture of one hectolitre of liqueur:—

Alcohol, 85°	25 litres.
Sugar	12 kilog., 500 grms.
Water	66 litres.

Essences,* the quantity prescribed in each receipt.

Fill a bottle of the capacity of one litre half full of alcohol; then pour in the essence; agitate quickly and thoroughly for one or two minutes; nearly fill the bottle with alcohol, and agitate again; pour this solution into a can, and pour thereon the balance of the alcohol; mix

* Essences, volatile oils.

well for some minutes; add the sugar, previously dissolved by the aid of heat, in the water; color, size, and filter according to the directions previously given.

Anisette.

Essence of	anise	30 grammes.
"	star anise	30 "
"	fennel	5 "
"	coriander	50 centigrammes.

Eau d'Angelique.

Essence of angelica . . . . 5 grammes.

Cent-Sept-Ans.

Essence of	lemons (distilled)	40 grammes.
"	roses	2 "

Color red with archil.

Curaçoa.

Essence of	curaçoa (distilled)	40 grammes.
"	Portugal "	15 "
"	cloves	2 "

Color a deep yellow with caramel.

Fleurs d'Oranger (Orange-flowers).

Essence of neroli (Paris) . . . 10 grammes.

Menthe (Peppermint).

Essence of mint . . . . . 20 grammes.

Eau de Noyaux.

Essence of noyaux . . . . 30 grammes.

Parfait Amour.

Essence of	lemon (distilled)	40 grammes.
"	cedrat "	15 "
"	coriander	1 gramme.

Color red with archil.

Huile de Roses.

Essence of roses	6 grammes.

Color red with archil.

Vespétro.

Essence of anise	20 grammes.
" caraway	15 "
" fennel	6 "
" coriander	2 "
" lemon (distilled)	8 "

Liqueurs Demi-Fines.

These liqueurs are prepared like the preceding, using for the manufacture of 100 litres the following quantities:—

Alcohol, 85°	28 litres.
Sugar	25 kilogrammes.
Water	55 litres.

Anisette.

Essence of anise	32 grammes.
" star anise	32 "
" fennel	6 "
" coriander	50 centigrammes.
" neroli (Paris)	1 gramme.

Crème d'Angelique.

Essence of angelica	7 grammes.

Crème de Celeri.

Essence of celery	15 grammes.

Cent-Sept-Ans.

Essence of lemon (distilled)	60 grammes.
" roses	5 "

Color red with cudbear.

Curaçoa.

Essence of curaçoa (distilled)	. .	50 grammes.
" Portugal "	. .	20 "
" cloves	. . . .	4 "

Color a deep yellow with caramel.

Crème de Fleurs d' Oranger.

Essence of neroli (Paris) . . . 12 grammes.

Crème de Menthe.

Essence of peppermint . . . 35 grammes.

Crème de Noyaux.

Essence of noyaux . . . . 40 grammes.

Parfait Amour.

Essence of lemon (distilled).	. .	50 grammes.
" cedrat "	. .	20 "
" coriander	. . . .	1 gramme.

Color red with cudbear.

Huile de Roses.

Essence of rose . . . . . 8 grammes.

Color red with cudbear.

Vespétro.

Essence of anise	. . . .	30 grammes.
" caraway	. . . .	20 "
" fennel	. . . .	6 "
" coriander	. . .	2 "
" lemon (distilled)	. .	10 "

Liqueurs Fines.

The process is the same as for the preceding, employing the following proportions for one hectolitre :—

Alcohol, 85°	. . .	32 litres.
Sugar	. . . .	43 kilog., 750 grammes.
Water	. . . .	39 litres.

Anisette.

Essence of	star anise	50 grammes.
"	anise	20 "
"	fennel	6 "
"	coriander	1 gramme.
"	sassafras	4 grammes.
Extract of	orris-root	40 "
"	ambergris	6 "

Crème d'Angelique.

Essence of angelica . . . . . 10 grammes.

Crème de Celeri.

Essence of celery . . . . 20 grammes.

Cent-Sept-Ans.

Essence of	lemon (distilled) . . .	70 grammes.
"	roses	4 "

Color red with cudbear.

Curaçoa.

Essence of	curaçoa (distilled) . .	70 grammes.
"	Portugal " . .	25 "
"	cloves	5 "

Bitter infusion of curaçoa, a sufficient quantity.

Color with logwood, or extract of logwood.

Eau de Vie de Dantzick.

Essence of	Ceylon cinnamon . .	4 grammes.
"	China cinnamon . . .	12 "
"	coriander	2 "
"	lemon (distilled) . .	25 "
"	Portugal (distilled) . .	8 "

Crème de Fleurs d'Oranger.

Essence of neroli (Paris) . . . 15 grammes.

Elixir of Garus.

Essence of China cinnamon	12	grammes.
" cloves	6	"
" nutmegs	2	"
Socotrine aloes	40	"
Myrrh	25	"
Saffron	4	"

After dissolving the essences, digest the aloes, myrrh, and saffron for three days in the alcohol.

Color a golden yellow with caramel.

Crème de Menthe.

Essence of peppermint . . . . 50 grammes.

Crème de Noyaux.

Essence of noyaux . . . . 50 grammes.

Parfait Amour.

Essence of lemon (distilled)	60	grammes.
" cedrat "	25	"
" coriander	2	"

Color red with cudbear.

Huile de Roses.

Essence of roses . . . . . 12 grammes.

Color red with cudbear.

Eau de Sept-Graines.

Essence of angelica	3	grammes.
" anise	15	"
" celery	5	"
" coriander	1	gramme.
" fennel	5	grammes.
" Portugal (distilled)	5	"
" lemon "	5	"

Color a bright yellow with caramel.

Vespétro.

Essence of anise	40	grammes.
" caraway	25	"
" fennel	6	"
" coriander	3	"
" lemon (distilled)	15	"

Liqueurs Surfines.

The proportions for the manufacture of one hectolitre of liqueur are—

Alcohol, 85°	30 litres.
Sugar	56 kilogrammes.
Water	26 litres.

The operation is the same as that described above.

Anisette.

Essence of star anise	70	grammes.
" anise	20	"
" fennel	8	"
" coriander	1	gramme.
" sassafras	6	grammes.
Extract of orris-root	60	"
" ambergris	8	"

Crème d'Absinthe.

Essence of absinthe	6	grammes.
" peppermint	6	"
" anise	30	"
" fennel	8	"
" lemon (distilled)	30	"

Crème d'Angelique.

Essence of angelica	15	grammes.
" coriander	2	"
" fennel	4	"

Crème de Barbades.

Essence of cedrat (distilled)	60	grammes.
" Portugal "	30	"
" Ceylon cinnamon	4	"
" cloves	4	"
" nutmegs	2	"

Crème de Celeri.

Essence of celery	. . . .	30 grammes.

Curaçoa.

Essence of curaçoa (distilled)	. .	100 grammes.
" Portugal "	. .	40 "

Bitter infusion of curaçoa, a sufficient quantity.

Color with logwood in chips, or the extract.

Liqueur dite de las Grande-Chartreuse.

Essence of lemon balm	. . .	2 grammes.
" hyssop	. . . .	2 "
" angelica	. . . .	10 "
" peppermint	. . .	20 "
" China cinnamon	. .	2 "
" nutmegs	. . . .	2 "
" cloves	. . . .	2 "

Color yellow or green, as may be required.

Eau de Vie de Dantzick.

Essence of Ceylon cinnamon	. .	5 grammes.
" China "	. .	15 "
" coriander	. . . .	2 "
" lemon (distilled)	. . .	30 "
" Portugal "	. . .	10 "

Crème de Fleurs d' Oranger.

Essence of neroli (Paris)	. . .	20 grammes.
Orange-flower water	. . . .	2 litres.

Elixir de Garus.

Essence of China cinnamon	. . .	15 grammes.
" cloves	. . . .	8 "
" nutmegs	. . . .	2 "
Socotrine aloes	. . . . .	50 "
Myrrh	. . . . . .	30 "
Saffron	. . . . . .	5 "

After dissolving the essences, digest the last three articles in the alcohol for three days.

Huile de Kirschenwasser.

Essence of noyaux	40	grammes.
" neroli (Paris)	4	"

Crème de Menthe.

Essence of peppermint	60	grammes.

Liqueur du Mezenc.

Essence of nutmegs	5	grammes.
" mace	2	"
" chamomile	10	"
" daucus	5	"
" coriander	3	"
Myrobolans	60	"
Muskmallow	60	"
Vanilla	60	"

After dissolving the essences, digest the last three named substances for 15 days in the alcohol; color with extract or chips of logwood, and add a small quantity of a solution of tartaric acid to brighten the color to a golden yellow.

Crème de Noyaux de Phalsbourg.

Essence of noyaux	50	grammes.
" bitter almonds	10	"
" Portugal (distilled)	10	"
" lemon (distilled)	8	"
" China cinnamon	4	"
" cloves	2	"
" nutmegs	1	gramme.
" neroli	2	grammes.

Crème de Roses.

Essence of roses	15	grammes.

Color red with cochineal.

Eau des Sept-Graines.

Essence of angelica	4	grammes.
" anise	20	"
" celery	6	"
" coriander	2	"
" fennel	4	"
" Portugal (distilled)	10	"

Color a bright yellow with caramel.

Vespétro de Montpellier.

Essence of anise	45	grammes.
" caraway	30	"
" fennel	8	"
" coriander	4	"
" lemon (distilled)	20	"

Anisette de Hollande.

Essence of star anise	50	grammes.
" anise	50	"
" bitter almonds	8	"
" coriander	1	gramme.
" fennel	2	grammes.
" roses	2	"
" angelica	4	"

Alkermès de Florence.

Essence of calamus	3	grammes.
" Ceylon cinnamon	2	"
" cloves	5	"
" nutmegs	3	"
" roses	4	"
Extract of jasmine	30	"
" orris-root	30	"

Impart a rose tint with cochineal.

Marasquin de Zara.

Essence of noyaux	35	grammes.
" neroli	5	"
" jasmine	10	"
" vanilla	15	"

Rosolio de Turin.

Essence of anise	25	grammes.
" fennel	3	"
" bitter almonds	30	"
" roses	6	"
Extract of ambergris and musk	4	"

Color a bright rose with cochineal.

Crème de Jasmin.

Extract of jasmin . . . . 150 grammes.

Crème de Jonquille.

Extract of jonquille . . . . 140 grammes.

Color a bright yellow with caramel.

Crème d'Heliotrope.

Extract of heliotrope . . . . 180 grammes.

Color a very bright rose with cochineal.

Crème de Réséda.

Extract of reseda . . . . 175 grammes.

Crème de Tubéreuse.

Extract of tuberose . . . . 150 grammes.

Crème de Millefleurs.

Essence of neroli	5	grammes.
" roses	2	"
Extract of jasmin	20	"
" jonquille	15	"
" heliotrope	25	"
" reseda	20	"
" tuberose	20	"

Remarks.—In time, liqueurs prepared from essences lose their perfume in a great measure, and acquire a rancid flavor. This last objection is often due to the inferior quality of the essences, which are for the most part mixed or old. The manufacturer should endeavor to purchase these products only from houses of the best reputation, and to take those only that are of the best quality, regardless of the price; for in this business, as in many others, *cheap goods cost very dear.*

CHAPTER XXV.

CORDIAL WINES.

WINES are generally divided into two very distinct sorts: *dry wines* (*vins secs*) and *sweet* or *cordial wines* (*vins sucrés*, or *vins de liqueurs*).

The cordial wines contain less water, more sugar and alcohol, and present a more decided perfume than the dry wines; they are of almost syrupy consistence, and of a sweetness which renders them rather pleasant *liqueurs* than wines for daily consumption.

The grapes for making cordial wines are prepared in several ways. In those countries where the temperature is high, and where the grape, when at maturity, is of a variety to afford sugar in abundance, the method most generally adopted consists in interrupting the vegetation by twisting the stem of the bunch of grapes on the vine, in order that the fruit may lose a portion of its water of vegetation by a natural desiccation under the action of the sun's rays. By another method, the grapes are dried after being cut, by exposing them to the action of the sun on hurdles. From these preparations, it happens that the abstraction of a portion of the moisture of the grape concentrates the saccharine principle, and destroys the equilibrium between it and the water which is necessary to the fruit.

The presence of water being absolutely necessary in the fermentation of wine, to enable the force of disorganization and new combination to exert itself on fermentable substances, it may be readily conceived that the juice of the grape is only subject to the laws of fermentation in proportion to the ratio which the water holds to the other principles which enter into the composition of the juice. Now, cordial wines are necessarily of the same nature as wines properly so called, with

the addition of the saccharine principle, which has failed to be fermented because of a deficiency of water; the molecules of the sugar are perfectly intermingled with the molecules of the wine; the two constitute a fluid which clarifies itself by rest, each of them serving as a support to the other; the wine, or rather the alcohol of the wine, opposes the fermentation of the sugar, and the latter in its turn prevents the wine from being converted into an acid, provided, however, that the liqueur is kept in close vessels.

When the juice or *must* of the grape is more watery than is proper, with regard to the proportion of the saccharine principle, the must is concentrated by evaporation over the fire; whereby the saccharine is rendered relatively more abundant than the aqueous principle.

The quality of the cordial wines is determined by the peculiar aroma and flavor which appertain to each kind, and which produce on the organs of taste a more or less decided vinous and saccharine sensation.

As a general rule, the cordial wines which are met with in the market are *factitious wines*,* manufactured for the most part at Cette and Montpellier; they are invariably the result of the admixture of different wines, alcohol, saccharine matter, and a *bouquet* extracted from various aromatic substances; the whole in proportions which have reference to the character and nature of the wines imitated.

The public in general are persuaded that factitious cordial wines are injurious to health; this is a great mistake. These wines contain no unhealthy or noxious materials, and are, on the contrary, for the most part, more healthy than certain natural wines.

It must not be suspected, however, that our object in publishing the methods of manufacturing cordial wines is to encourage the fraud which sells the imitations for natural wines; it is only for the purpose of making

* This term is not altogether proper; that of *mixed wines* would be preferable, since whatever be the character of the wine it is desired to manufacture, it must always be the product of a mixture of wines.

known all the processes employed in the south of France; we would, on the contrary, urgently advise dealers who sell these wines for consumption to indicate on their labels and invoices that they are imitations, and are not genuine.

Imitation of Cordial Wines.

The constituent elements of cordial wines being known, nothing more is required to obtain a good result than to mix them with skill, and aromatize them properly. For this purpose various preparations are used, such as *syrup of raisins* (*sirop de raisin*); *infusion of green walnuts* (*noix verte*); *infusion of toasted bitter almond hulls* (*coques d'amandes amères torréfiées*); *infusion of Florentine iris; spirit of raspberries* (*framboises*); *spirit of tar* (*goudron*).

Before making known the receipts by means of which the cordial wines may be imitated, it is necessary to indicate the method of preparing the spirit of tar and the infusion of toasted bitter almond hulls, the only liquids required for these imitations which we have not heretofore noticed.

Spirit of Tar.

Norway tar	500 grammes.
Alcohol, 85°	2 litres.
Water	1 litre.

Distill the whole carefully in a glass retort, over a sand-bath, until two litres are drawn off.

Infusion of Toasted Bitter Almond Hulls.

Hulls of bitter almonds	5 kilog., 500 grms.
Alcohol, 85°	20 litres.

Toast the almond hulls in a coffee toaster, and, while yet hot, throw them into the vessel containing the alcohol; lute carefully, to prevent evaporation; allow them to infuse one month; then draw off the clear liquid, and filter.

Receipts for Cordial Wines.

As in the case of the liqueurs, the receipts which follow are all applicable to the manufacture of one hectolitre of liquid.

Alicante.

Old wine of Bagnols . .	90 litres.
Syrup of raisins, 85° . .	5 "
Infusion of orris-root . .	1 litre, 25 centilitres.
" walnut hulls .	1 " 10 "
Alcohol, 85°	3 litres.

Mix carefully and allow it to stand for two months; then size with gelatine (15 grammes dissolved in half a glass of water), and after 8 days draw off.

Cyprus.

Very old wine of Bagnols .	86 litres.
Infusion of orris-root . .	1 litre, 10 centilitres.
" walnut hulls .	1 " 10 "
Toasted hulls of bitter almonds	2 litres.
Syrup of raisins, 35° . .	5 "
Alcohol, 85°	5 "

Operate as above.

Constance.

Very old wine of Bagnols .	88 litres.
Infusion of orris-root . .	1 litre.
Spirit of raspberries. . .	2 litres, 25 centilitres.
" tar . . .	15 grammes.
Syrup of raisins, 35° . .	5 litres.
Alcohol, 85° . . .	5 "

Operate as above.

Grenache.

Old Collioure wine . . .	89 litres.
Syrup of raisins, 35° . . .	6 "
Infusion of walnut hulls . .	1 litre, 25 centils.
" toasted bitter almond hulls	1 "
Alcohol, 85°	3 litres.

Mix as above.

Malaga.

Old Bagnols wine	90 litres.
Syrup of raisins, 35°	5 "
Infusion of walnut hulls . . .	2 "
Spirit of tar	30 grammes.
Alcohol, 85°	3 litres.

Mix as above.

Malvoisie de Madère.

Sweet wine of Picardy	88 litres.
Infusion of toasted bitter almond hulls	2 "
Spirit of raspberries	2 "
Elder flowers	500 grammes.
Syrup of raisins, 35°	5 litres.
Alcohol, 85°	3 "

Mix as above.

Muscat de Lunel.

Sweet wine of Picardy . . .	90 litres.
Syrup of raisins, 35°	6 "
Elder flowers	750 grammes.
Alcohol, 85°	4 litres.

Place the flowers in a net; let them infuse in the liquid for 2 months, and mix as above.

Muscat de Frontignan.

Dry wine of Picardy	82 litres.
Syrup of raisins, 35°	10 "
Elder flowers	250 grammes.
Alcohol, 85°	8 litres.

Operation, in every respect, as above.

Madeira (Madère).

Dry wine of Picardy	90 litres.
Infusion of walnut hulls	2 "
" toasted bitter almond hulls .	2 "
Syrup of raisins, 35°	2 "
Alcohol, 85°	4 "

Mix in the same manner as wine of Alicante.

Sherry (Xérès).

Very old dry wine of Picardy	88 litres.	
Infusion of walnut hulls	2 "	
" toasted bitter almond hulls	3 "	50 centils.
Syrup of raisins, 35°	2 "	
Alcohol, 85°	5 "	

Operate as above.

Sherry Cordial.

Very old dry wine of Picardy	85 litres.
Infusion of walnut hulls	1 litre.
" toasted bitter almond hulls	3 litres.
" orris-root	1 litre.
Syrup of raisins, 35°	8 litres.
Alcohol, 85°	2 "

Operation as above.

Lacryma-Christi.

Very old Bagnols wine	86 litres.
Tincture of catechu	1 litre.
Infusion of walnut hulls	1 "
" orris-root	1 "
Syrup of raisins, 35°	6 litres.
Alcohol, 85°	5 "

Operate as above.

Port (Porto).

Old Collioure wine	83 litres.
Infusion of black cherries (*merises*)	5 "
" walnut hulls	2 "
Spirit of raspberries	2 "
Syrup of raisins, 35°	5 "
Alcohol, 55°	3 "

Operate as above.

Rota.

Old Collioure wine	88 litres.
Infusion of walnut hulls	2 "
" toasted bitter almond hulls	1 litre.
Spirit of raspberries	2 litres.
Syrup of raisins, 35°	5 "
Alcohol, 85°	2 "

Operate as above.

Tokai.

Very old Bagnols wine	86 litres.
Infusion of walnut hulls	1 litre.
" orris-root	1 "
Spirit of raspberries	2 litres.
Syrup of raisins, 35°	6 "
Alcohol, 85°	4 "

Operate as above.

Remark.—All wines improve with age, but especially the cordial wines; they should never be sold for consumption until after the dealer has satisfied himself that they are as near perfection as possible. Limpidity is of essential importance.

Vermout de Turin.

Large absinthe	125 grammes.
Gentian	60 "
Angelica (roots)	60 "
Holy thistle (*centaurea benedicta*)	125 "
Calamus aromaticus	125 "
Elacampane	125 "
Lesser centaury	125 "
Small germander (*chamaedrys*)	125 "
China cinnamon	100 "
Nutmegs	15 "
Fresh oranges, cut in slices	6 (in number).
Sweet wine of Picpoul	95 litres.
Alcohol, 85°	5 "

Digest for five days, draw off the clear liqueur, size with fish sounds; after a rest of eight days, rack it off and size again before putting it in bottles.

The Picpoul wine may be replaced by dry Picardy wine, in which case five litres of syrup of raisins, at 35°, are to be added. Vermout is commonly made at Montpellier, Cette, and Lyons.

Frequently its bitterness is too decided, and it is necessary to correct it by the addition of more wine. The following is a combination which is always acceptable.

Bitter Vermout	50 litres.
Common white wine (*vin ordinaire*) . .	42 "
Syrup of raisins	4 "
Infusion of toasted bitter almond hulls .	1 litre.
Alcohol, 85°	4 litres.

Color a golden yellow with caramel, and size twice as for the preceding.

Vermout d'Italie (*Receipt of Ollivero*).

Coriander	500 grammes.
Rinds of bitter oranges . . .	250 "
Orris-root in powder	250 "
Elder flowers	200 "
Cinchona (red)	150 "
Calamus	150 "
Larger absinthe	125 "
Elecampane (roots)	125 "
Lesser centaury	125 "
Germander (less)	125 "
China cinnamon	100 "
Angelica (roots)	60 "
Nutmegs	50 "
Galanga	50 "
Cloves	50 "
Cassiæ (flower buds)	30 "
Dry white wine of Picardy . .	100 litres.

Digest for five or six days, draw off the clear liqueur, size with fish glue, and allow it to stand fifteen days.

Vermout of the best quality will be obtained if we add to this preparation two litres of the infusion of toasted bitter almond hulls, and three litres of good Cognac.

Vermout au Madère.

Grand absinthe	125	grammes.
Angelica (roots)	60	"
Holy thistle	125	"
Lungwort (*pulmonaire*)	125	"
Veronica	125	"
Rosemary	125	"
Rhubarb	30	"
Cinchona (red)	200	"
Orris-root in powder	250	"
Infusion of curaçoa	25	centilitres.
Common Madeira wine	92	litres.
Syrup of raisins	3	"
Cognac	5	"

Digest for three days, draw off the clear liqueur, size with fish sounds; after a rest of eight days, rack off and size again before boiling.

Madeira wine may be replaced by dry Picardy, to which are added two litres of the infusion of toasted hulls of bitter almonds.

Factitious Effervescing Wines.

The manufacture of champagne wines is the object of a special trade, and we regret that the limits of this work forbid our entering into the details of the various preparations. We may, however, be permitted to introduce a short notice of a factitious effervescing wine, which is readily prepared, and which may well take the place of much of the vile stuff sold under that name.

All wines may be rendered effervescent, but light wines which preserve their whiteness should have the preference. Before using them, it is necessary to size and rack them off at least twice, in order to prevent their leaving a deposit in the bottles; then sweeten them properly, that is to say, having an eye to the nature of the wine. In order to make a good imitation of champagne, it is best to use sugar candy, and to select that which is very white.

The following is the method of preparing the *liqueur* which is to be added to the wine before rendering it effervescent:—

Take 5 kilogrammes of sugar candy, and dissolve it in 5 litres of white wine; after it is perfectly dissolved, add 3 litres and 50 centilitres of white Cognac brandy at 58°, and 5 grammes of tincture of vanilla;* mix and filter.

The liquor being prepared, add 70 litres of white wine, and put the whole into a glass-lined fountain of proper dimensions, and connect with an apparatus for preparing aerated mineral water, suffer the liquid to absorb the carbonic acid gas until the pressure equals six atmospheres. Beyond this the wine will become too acid.

It may be remarked that wine absorbs gas in proportion as it is rich in alcohol.

The wine being properly charged with gas, draw it off into bottles with a suitable apparatus, secure the corks in the usual way with twine and wire, then cover the heads with tinfoil, and label.

The product of this manufacture will be 100 bottles containing 80 centilitres each.

The rose-tinted, foaming wine is prepared by adding to each bottle two or three drops of coloring, made by infusing elder berries in brandy. This liqueur is very highly charged with color. The color may be imparted by using a very dark red wine in the proportion of ten per cent.

* This tincture is prepared by macerating 200 grammes of vanilla in 1 litre of spirit at 85°, for 15 days.

CHAPTER XXVI.

NEW METHOD OF DISTILLING IN A VACUUM.

For a long time pharmaceutists and liquorists have sought in vain for some easy and simple method of distilling and concentrating fluids in a vacuum. This interesting problem has been happily solved by M. Egrot; that skilful manufacturer has recently taken out a patent for a new apparatus, which may be used in the manufacture and concentration of pharmaceutical extracts, and answers equally well for the distillation of aromatic and other waters, as well as alcoholic tinctures (perfumed spirits) either in a vacuum or under the free pressure of the atmosphere.

This apparatus, which may be heated by steam, or the naked fire is represented in Pl. X., Fig. 1 and 2, heated by the latter method.

Method of Setting the Apparatus in Operation.—The boiler *A* is filled with water to about three-fourths; the level of the water is indicated by the glass tube *f*; the fire is then lighted until the water begins to boil, the steam escapes by the pipe *k*, passing through the cock *j*, into the evaporator *B*; being continually renewed, the steam fills this piece and passes by the pipe *q* into the receiver *C*, to escape at last from the apparatus by the escape-pipe *t* and the cock *U*. When the steam escapes by this last pipe, a large portion of the air contained in the apparatus has been driven out, but it is better to allow the steam to blow off for twelve or fifteen minutes, in order that the air may be entirely expelled. The cock *U* is then closed, and next the cock *j*. The escape-pipe of the boiler *A* is now opened, and at the same time the door of the ash-pit is closed, or the fire covered with cinders, so as to check its action

(further on will be found a description of the section of the furnace), and the fire should be maintained in this condition during the whole operation.

When everything has been arranged as above, the cock *l* of the pipe which dips into a vessel containing the liquid to be concentrated or distilled, is opened; immediately this liquid, in consequence of the vacuum formed in the apparatus, begins to flow into the evaporator *B*, until it rises to the line *f′*; when the liquid has attained this level, the cock *l* is closed, and ten minutes afterwards the evaporation or distillation begins, or, in other words, the liquid begins to boil.

If the ebullition does not appear to be sufficiently active, as may be seen through the lunette *n*, a small stream of water is turned into the funnel *y*, and immediately the ebullition will be vigorously set up, especially when the liquid evaporated is very frothy. It is on this account that, at the beginning of the operation, a very small quantity of cold water must be allowed to flow into the cooler; the operation progressing regularly, the cooler fills with water, which should remain cool at the lower portion and tepid above. The water escapes by the overflow at *z*.

The apparatus thus started, continues in operation so long as there is liquid in the evaporator. It requires but little supervision, which consists in—

1. Examining if the fire is too active, or whether it is dying out: the fire is known to be too active when, on looking through the lunette *n*, the ebullition is observed to be too tumultuous, or if the evaporator is too hot for the hand.

2. To regulate the stream of water in the cooler. It is not necessary to pay so much attention to the fire; but in most cases it ought to bear an equal part in regulating the ebullition of the liquid.

The evaporation is complete when the liquid or extract has been concentrated to the proper degree.

When there is a certain quantity of liquid to be evaporated, and it is not desirable to commence another operation, that is to say, to unlute and lute the apparatus

anew, the charge is renewed on the extract already manufactured by opening the cock l, which dips into the liquid, the suction acts as before, and the evaporator is again filled to the line f'. After having concentrated this second charge with the first, the charge may be renewed a third time or even oftener, until the evaporator contains too much extract to be operated properly, then the cock l, which should no longer be connected with any liquid, should be opened, and the operation is at once suspended by the introduction of air into the evaporator; the cock U is then opened to allow the evaporated liquid to escape from the receiver; then the cock x to discharge the water from the cooler. Finally, remove the joint clasps PP, and remove the receiver from the evaporator; then with a dipper or a spatula, as the product is liquid or semi-fluid, remove it from the apparatus.

Sometimes, when very frothy liquids are treated, which from their nature will pass without being volatilized from the evaporator B into the receiver C, a small piece called a *froth arrester* is used; it being placed at the entrance to the pipe q (see Figs. 3 and 4); in Fig. 3, this piece is represented in section through its vertical axis.

a. A pipe expanding below in the form of a funnel, and supporting at its widest portion a sheet of metallic cloth, the straight portion forming a tube is introduced into the pipe q, and is maintained in position by simple adjustment; it may be used or not at pleasure.

b b. Straps riveted on the part a, and connecting with the inverted cone c, the base of which returns so as to form a flange.

The action of this little apparatus is as follows: the liquid contained in the evaporator beginning to rise, first comes in contact with the inverted cone, which by its form forces the frothing liquid back, and reduces the effervescence; the froth attempting to overcome this resistance, is broken and arrested by the metallic cloth placed immediately above the cone c.

Among the different parts which compose the vacuum evaporator, there are two which are not represented in

the figures of Plate X. These pieces attached to the boiler *B*, are: 1. A safety-valve to prevent too great a pressure between the boiler and the evaporator; 2. A screw plug for filling the boiler with water, and in case of necessity to act as an escape-pipe for steam from the boiler.

Fig. 2 represents a section, in elevation, of the furnace on which the evaporating apparatus is to be placed.

a a. Brick walls laid in mortar.

b. Fireplace; this portion of the furnace should be very conical.

c c c. Very thin bars forming the grate; this last should have but a small surface, in order to have the fire under more thorough control.

D. Ash-pit. It is important that this should be capable of being well closed, in case it is desired to reduce or extinguish the fire.

e e e. Flues through which the heat may circulate freely and be more thoroughly economized.

The advantages presented by this apparatus, which has been tested by the Imperial Academy of Medicine, are remarkable, viz.:—

1. By its simplicity of construction, as well as the economy and perfection of the workmanship, the entrance of air is impossible.

2. By a single joint which connects the ordinary receiver to the evaporator; this joint, extremely easy of adjustment (an essential point in an apparatus which is to be dismounted frequently), consists of two circles of copper *o o'*, of which one is soldered to the evaporator, and the other to the receiver; these two pieces, as indicated in the illustration, are finished on their outer surfaces into a cone; between these two circles is placed a washer of vulcanized rubber of at least four millimeters in thickness; then the joint is closed by means of a movable circle or clamp (*serre-joint*).

The form of this new apparatus of M. Egrot, its combinations, and the arrangement of its joints, render the use of the pneumatic pump useless, since they are sufficient to produce a vacuum.

This apparatus may be used as a still for distilling in a vacuum, or under the free pressure of the air. When distilling in the open air, the cock *U* is left open, and the steam or vapor rising from the evaporator *B* is condensed in the receiver *C*, and escapes by the cock. If, on the other hand, the distilling is conducted in a vacuum, it will be necessary to conduct the operation as described at the beginning of this article, and collect the product of the condensed vapors in the receiver *C*.

In case it is desired to distill seeds or plants, it will be necessary to place them on the grating *x x*, which is arranged for that purpose, and by means of the pipe *z* screwed to the cock for the introduction of the steam coming from the boiler under the grate, where it escapes and passes through the aromatic plants. This grate and the pipe *z* may be removed when the apparatus is required for other purposes.

APPENDIX.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

THE United States being the first to introduce the decimal system into the coinage of the country, and to demonstrate its superior utility, it is remarkable that we have hesitated so long in regard to the substitution of the same simple and rational system of weights and measures for the complicated and confused standards in general use.

In May, 1866, the Committee on Coinage, Weights, and Measures presented to the House of Representatives an exhaustive report, accompanied by bills authorizing the introduction of the *metric system* into the various departments of trade, and making all contracts, based on this system of weights and measures, valid before any court in the United States. They said:—

"THE METRIC SYSTEM.

"It is orderly, simple, and perfectly harmonious, having useful relations between all its parts. It is based on the METER, which is the principal and only arbitrary unit. The meter is a measure of length, and was intended to be, and is, very nearly one ten-millionth of the distance on the earth's surface from the equator to the pole. It is 39.37 inches, very nearly.

"The *are* is a surface equal to a square whose side is 10 meters. It is nearly four square rods.

"The *liter* is the unit for measuring capacity, and is equal to the contents of a cube whose edge is a tenth part of the meter. It is a little more than a wine quart.

"The *gramme* is the unit of weight, and is the weight of a cube of water, each edge of the cube being one one-hundredth of the meter. It is equal to 15.432 grains.

"The *stere* is the cubic meter.

"Each of these units is divided decimally, and larger units are formed by multiples of 10, 100, &c. The successive multiples are designated by the prefixes, *deka*, *hecto*, *kilo*, and *myria*; the subordinate parts by *deci*, *centi*, and *milli*, each having its own numerical significance.

"The nomenclature, simple as it is in theory, and designed

from its origin to be universal, can only become familiar by use. Like all strange words, these will become familiar by custom, and obtain popular abbreviations. A system which has incorporated with itself so many different series of weights, and such a nomenclature as 'scruples,' 'pennyweights,' 'avoirdupois,' and with no invariable component word, can hardly protest against a nomenclature whose leading characteristic is a short component word with a prefix signifying number. We are all familiar with *thermometer*, *barometer*, *diameter*, *gasometer*, &c., with *telegram*, *monogram*, &c., words formed in the same manner.

"After considering every argument for a change of nomenclature, your committee have come to the conclusion that any attempt to conform it to that in present use would lead to confusion of weights and measures, would violate the early learned order and simplicity of metric denomination, and would seriously interfere with that universality of system so essential to international and commercial convenience.

"When it is remembered that of the value of our exports and imports, in the year ending June 30, 1860, in all $762,000,000, the amount of near $700,000,000 was with nations and their dependencies that have now authorized, or taken the preliminary steps to authorize, the metric system, even denominational uniformity for the use of accountants in such vast transactions assumes an important significance. In words of such universal employment, each word should represent the identical thing intended, and no other, and the law of association familiarizes it.

"Your committee unanimously recommend the passage of the bills and joint resolutions appended to this report. . . . . . The metric system is already used in some arts and trades in this country, and is especially adapted to the wants of others. Some of its measures are already manufactured at Bangor, in Maine, to meet an existing demand at home and abroad. The manufacturers of the well-known Fairbanks' scales state: 'For many years we have had a large export demand for our scales with French weights, and the demand and sale are constantly increasing.' Its minute and exact divisions specially adapt it to the use of chemists, apothecaries, the finer operations of the artisan and to all scientific objects. It has always been and is now used in the United States coast survey. Yet in some of the States, owing to the phraseology of their laws, it would be a direct violation of them to use it in the business transactions of the community. It is, therefore, very important to legalize its use, and to give to the people, or that portion of them desiring it, the opportunity for its legal employment, while the knowledge of its characteristics will be thus diffused among men."

TABLES

SHOWING THE

RELATIVE VALUES OF FRENCH AND ENGLISH WEIGHTS AND MEASURES, &c.

Measures of Length.

Millimetre	=	0.03937	inch.
Centimetre	=	0.393708	"
Decimetre	=	3.937079	inches.
Metre	=	39.37079	"
"	=	3.2808992	feet.
"	=	1.093633	yard.
Decametre	=	32.808992	feet.
Hectometre	=	328.08992	"
Kilometre	=	3280.8992	"
"	=	1093.633	yards.
Myriametre	=	10936.33	"
"	=	6.2138	miles.
Inch ($\frac{1}{36}$ yard)	=	2.539954	centimetres.
Foot ($\frac{1}{3}$ yard)	=	3.0479449	decimetres.
Yard	=	0.91438348	metre.
Fathom (2 yards)	=	1.82876696	"
Pole or perch ($5\frac{1}{2}$ yards)	=	5.029109	metres.
Furlong (220 yards)	=	201.16437	"
Mile (1760 yards)	=	1609.3149	"
Nautical mile	=	1852	"

Superficial Measures.

Square millimetre	=	$\frac{1}{645}$	square inch.
" "	=	0.00155	" "
" centimetre	=	0.155006	" "
" decimetre	=	15.50059	" inches.
" "	=	0.107643	" foot.
" metre or centiare	=	1550.05989	" inches.
" " "	=	10.764299	" feet.
" " "	=	1.196033	" yard
Are	=	1076.4299	" feet.
"	=	119.6033	" yards.
"	=	0.098845	rood.
Hectare	=	11960.3326	square yards.
"	=	2.471143	acres.
Square inch	=	645.109201	square millimetres.
" "	=	6.451367	" centimetres
" foot	=	9.289968	" decimetres.
" yard	=	0.836097	" metre.
" rod or perch	=	25.291939	" metres.
Rood (1210 sq. yards)	=	10.116775	ares.
Acre (4840 sq. yards)	=	0.404671	hectare.

Measures of Capacity.

Cubic millimetre	=	0.000061027	cubic inch.
" centimetre or millilitre	=	0.061027	" "
10 " centimetres or centilitre	=	0.61027	" "
100 " " " decilitre	=	6.102705	" inches.
1000 " " " litre	=	61.0270515	" "
" " " " "	=	1.760773	imp'l pint.
" " " " "	=	0.2200967	" gal'n.
Decalitre	=	610.270515	cubic inches.
"	=	2.2009668	imp. gal'ns.
Hectolitre	=	3.531658	cubic feet.
"	=	22.009668	imp. gal'ns.
Cubic metre or stere or kilolitre	=	1.30802	cubic yard.
" " "	=	35.3165807	" feet.
Myrialitre	=	353.165807	" "

Cubic inch	=	16.386176	cubic centimetres.
" foot	=	28.315312	" decimetres.
" yard	=	0.764513422	" metre.

American Measures.

Winchester or U.S. gallon (231 cub.in.)	=	3.785209	litres.
" " bushel (2150.42 cub. in.)	=	35.23719	"
Chaldron (57.25 cubic feet)	=	1621.085	"

British Imperial Measures.

Gill	=	0.141983	litre.
Pint ($\frac{1}{8}$ gallon)	=	0.567932	"
Quart ($\frac{1}{4}$ gallon)	=	1.135864	"
Imperial gallon (277.2738 cub. in.)	=	4.54345797	litres.
Peck (2 gallons)	=	9.0869159	"
Bushel (8 gallons)	=	36.347664	"
Sack (3 bushels)	=	1.09043	hectolitre.
Quarter (8 bushels)	=	2.907813	hectolitres.
Chaldron (12 sacks)	=	13.08516	"

Weights.

Milligramme	=	0.015438395	troy grain.
Centigramme	=	0.15438395	" "
Decigramme	=	1.5438395	" "
Gramme	=	15.438395	" grains.
"	=	0.643	pennyweight.
"	=	0.0321633	oz. troy.
"	=	0.0352889	oz. avoirdupois.
Decagramme	=	154.38395	troy grains.
"	=	5.64	drachms avoirdupois.
Hectogramme	=	3.21633	oz. troy.
"	=	3.52889	oz. avoirdupois.
Kilogramme	=	2.6803	lbs. troy.
"	=	2.205486	lbs. avoirdupois.
Myriagramme	=	26.803	lbs. troy.
"	=	22.05486	lbs. avoirdupois.

Quintal metrique = 100 kilog. = 220.5486 lbs. avoirdupois.
Tonne = 1000 kilog. = 2205.486 " "

3

Different authors give the following values for the gramme:—

Gramme	=	15.44402	troy grains.
"	=	15.44242	"
"	=	15.4402	"
"	=	15.433159	"
"	=	15.43234874	"

AVOIRDUPOIS.

Long ton = 20 cwt. = 2240 lbs.	=	1015.649	kilogrammes.
Short ton (2000 lbs.)	=	906.8296	"
Hundred weight (112 lbs.)	=	50.78245	"
Quarter (28 lbs.)	=	12.6956144	"
Pound = 16 oz. = 7000 grs.	=	453.4148	grammes.
Ounce = 16 dr'ms. = 437.5 grs.	=	28.3375	"
Drachm = 27.344 grains	=	1.77108	gramme.

TROY (PRECIOUS METALS).

Pound = 12 oz. = 5760 grs.	=	373.096	grammes.
Ounce = 20 dwt. = 480 grs.	=	31.0913	"
Pennyweight = 24 grs.	=	1.55457	gramme.
Grain	=	0.064773	"

APOTHECARIES' (PHARMACY).

Ounce = 8 drachms = 480 grs.	=	31.0913	gramme.
Drachm = 3 scruples = 60 grs.	=	3.8869	"
Scruple = 20 grs.	=	1.29546	gramme.

CARAT WEIGHT FOR DIAMONDS.

1 carat = 4 carat grains = 64 carat parts.

"	= 3.2	troy grains.	
"	= 3.273	"	"
"	= 0.207264	gramme	
"	= 0.212	"	
"	= 0.205	"	

Great diversity in value.

4

Proposed Symbols for Abbreviations.

M—myria — 10000	Mm	Mg	Ml	
K—kilo — 1000	Km	Kg	Kl	
H—hecto — 100	Hm	Hg	Hl	Ha
D—deca — 10	Dm	Dg	Dl	Da
Unit — 1	metre—m	gramme—g	litre—l	are—a
d—deci — 0.1	dm	dg	dl	da
c—centi — 0.01	cm	cg	cl	ca
m—milli — 0.001	mm	mg	ml	

Km = Kilometre. Hl = Hectolitre. cg = centigramme. c. cm = $\overline{cm}^3$ = cubic centimetre. $\overline{dm}^2$ = sq. dm = square decimetre. Kgm = Kilogrammetre. Kg° = Kilogramme degree.

Celsius or Centigrade.	Fahrenheit.	Réaumur.
— 15°	+ 5°	— 12°
— 10	+ 14	— 8
— 5	+ 23	— 4
0 melting	+ 32	ice 0
+ 5	+ 41	+ 4
+ 10	+ 50	+ 8
+ 15	+ 59	+ 12
+ 20	+ 68	+ 16
+ 25	+ 77	+ 20
+ 30	+ 86	+ 24
+ 35	+ 95	+ 28
+ 40	+104	+ 32
+ 45	+113	+ 36
+ 50	+122	+ 40
+ 55	+131	+ 44
+ 60	+140	+ 48
+ 65	+149	+ 52
+ 70	+158	+ 56
+ 75	+167	+ 60
+ 80	+176	+ 64
+ 85	+185	+ 68
+ 90	+194	+ 72
+ 95	+203	+ 76
+100 boiling	+212	water + 80
+200	+392	+160
+300	+572	+240
+400	+752	+320
+500	+932	+400

$$1^\circ \text{ C.} = 1^\circ.8 \text{ Ft.} = \tfrac{9}{5}^\circ \text{ Ft.} = 0^\circ.3 \text{ R.} = \tfrac{4}{5}^\circ \text{ R.}$$

1° C. $\times \frac{9}{5} = 1^\circ$ Ft. $\quad 1^\circ$ Ft. $\times \frac{5}{9} = 1^\circ$ C. $\quad 1^\circ$ R. $\times \frac{9}{4} = 1^\circ$ Ft.

1° C. $\times \frac{4}{5} = 1^\circ$ R. $\quad 1^\circ$ Ft. $\times \frac{4}{9} = 1^\circ$ R. $\quad 1^\circ$ R. $\times \frac{5}{4} = 1^\circ$ C.

Calorie (French) = unit of heat
= kilogramme degree } English.

It is the quantity of heat necessary to raise 1° C. the temperature of 1 kilogramme of distilled water.

Kilogrammetre = Kgm = the power necessary to raise 1 kilogramme, 1 metre high, in one second. It is equal to $\frac{1}{75}$ of a French horse power. An English horse power = 550 foot pounds, while a French horse power = 542.7 foot pounds.

Ready-made Calculations.

No. of units.	Inches to centimetres.	Feet to metres.	Yards to metres.	Miles to Kilometres.	Millimetres to inches.
1	2.53995	0.3047945	0.91438348	1.6093	0.03937079
2	5.0799	0.6095890	1.82876696	3.2186	0.07874158
3	7.6199	0.9143835	2.74315044	4.8279	0.11811237
4	10.1598	1.2197680	3.65753392	6.4373	0.15748316
5	12.6998	1.5239724	4.57191740	8.0466	0.19685395
6	15.2397	1.8287669	5.48630088	9.6559	0.23622474
7	17.7797	2.1335614	6.40068436	11.2652	0.27559553
8	20.3196	2.4383559	7.31506784	12.8745	0.31496632
9	22.8596	2.7431504	8.22945132	14.4838	0.35433711
10	25.3995	3.0479450	9.14383480	16.0930	0.39370790

No. of units.	Centimetres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.	Square inches to square centimetres.
1	0.3937079	3.2808992	1.093633	0.6213824	6.45136
2	0.7874158	6.5617984	2.187266	1.2427648	12.90272
3	1.1811237	9.8426976	3.280899	1.8641472	19.35408
4	1.5748316	13.1235968	4.374532	2.4855296	25.80544
5	1.9685395	16.4044960	5.468165	3.1069120	32.25680
6	2.3622474	19.6853952	6.561798	3.7282944	38.70816
7	2.7559553	22.9662944	7.655431	4.3496768	45.15952
8	3.1496632	26.2471936	8.749064	4.9710592	51.61088
9	3.5433711	29.5280928	9.842697	5.5924416	58.06224
10	3.9370790	32.8089920	10.936330	6.2138240	64.51360

No. of units.	Square feet to sq. metres.	Sq. yards to sq. metres.	Acres to hectares.	Square centimetres to sq. inches.	Sq. metres to sq. feet.
1	0.0929	0.836097	0.404671	0.155	10.7643
2	0.1858	1.672194	0.809342	0.310	21.5286
3	0.2787	2.508291	1.204013	0.465	32.2929
4	0.3716	3.344388	1.618684	0.620	43.0572
5	0.4645	4.180485	2.023355	0.775	53.8215
6	0.5574	5.016582	2.428026	0.930	64.5858
7	0.6503	5.852679	2.832697	1.085	75.3501
8	0.7432	6.688776	3.237368	1.240	86.1144
9	0.8361	7.524873	3.642039	1.395	96.8787
10	0.9290	8.360970	4.046710	1.550	107.6430

No. of units.	Square metres to sq. yards.	Hectares to acres.	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.
1	1.196033	2.471143	16.3855	0.02831	0.76451
2	2.392066	4.942286	32.7710	0.05662	1.52902
3	3.588099	7.413429	49.1565	0.08494	2.29354
4	4.784132	9.884572	65.5420	0.11325	3.05805
5	5.980165	12.355715	81.9275	0.14157	3.82257
6	7.176198	14.826858	98.3130	0.16988	4.58708
7	8.372231	17.298001	114.6985	0.19819	5.35159
8	9.568264	19.769144	131.0840	0.22651	6.11611
9	10.764297	22.240287	147.4695	0.25482	6.88062
10	11.960330	24.711430	163.8550	0.28315	7.64513

No. of units.	Cubic centimetres to cubic inches.	Litres to cubic inches.	Hectolitres to cubic feet.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1	0.06102	61.02705	3.5317	35.31659	1.30802
2	0.12205	122.05410	7.0634	70.63318	2.61604
3	0.18308	183.08115	10.5951	105.94977	3.92406
4	0.24411	244.10820	14.1268	141.26636	5.23208
5	0.30514	305.13525	17.6585	176.58295	6.54010
6	0.36617	366.16230	21.1902	211.89954	7.84812
7	0.42720	427.18935	24.7219	247.21613	9.15614
8	0.48823	488.21640	28.2536	282.53272	10.46416
9	0.54926	549.24345	31.7853	317.84931	11.77218
10	0.61027	610.27050	35.3166	353.16590	13.08020

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No. of units.	Grains to grammes.	Ounces avoir. to grammes.	Ounces troy to grammes.	Pounds avoir. to kilogrammes.	Pounds troy to kilogrammes.
1	0.064773	28.3375	31.0913	0.4534148	0.373096
2	0.129546	56.6750	62.1826	0.9068296	0.746192
3	0.194319	85.0125	93.2739	1.3602444	1.119288
4	0.259092	113.3500	124.3652	1.8136592	1.492384
5	0.323865	141.6871	155.4565	2.2670740	1.865480
6	0.388638	170.0250	186.5478	2.7204888	2.238576
7	0.453411	198.3625	217.6391	3.1739036	2.611672
8	0.518184	226.7000	248.7304	3.6273184	2.984768
9	0.582957	255.0375	279.8217	4.0807332	3.357864
10	0.647730	283.3750	310.9130	4.5341480	3.730960

No. of units.	Long tons to tonnes of 1000 kilog.	Pounds per square inch to kilogrammes per square centimetre.	Grammes to grains.	Grammes to ounces avoir.	Grammes to ounces troy.
1	1.015649	0.0702774	15.438395	0.0352889	0.0321633
2	2.031298	0.1405548	30.876790	0.0705778	0.0643266
3	3.046947	0.2108322	46.315185	0.1058667	0.0964899
4	4.062596	0.2811096	61.753580	0.1411556	0.1286532
5	5.078245	0.3513870	77.191975	0.1764445	0.1608165
6	6.093894	0.4216644	92.630370	0.2117334	0.1929798
7	7.109543	0.4919418	108.068765	0.2470223	0.2251431
8	8.125192	0.5622192	123.507160	0.2823112	0.2573064
9	9.140841	0.6324966	138.945555	0.3176001	0.2894697
10	10.156490	0.7027740	154.383950	0.3528890	0.3216330

No. of units.	Kilogrammes to pounds avoirdupois.	Kilogrammes to pounds troy.	Metric tonnes of 1000 kilog. to long tons of 2240 pounds.	Kilog. per square millimetre to pounds per square inch.	Kilog. per square centimetre to pounds per square inch.
1	2.205486	2.6803	0.9845919	1422.52	14.22526
2	4.410972	5.3606	1.9691838	2845.05	28.45052
3	6.616458	8.0409	2.9537757	4267.57	42.67578
4	8.821944	10.7212	3.9383676	5690.10	56.90104
5	11.027430	13.4015	4.9229595	7112.63	71.12630
6	13.232916	16.0818	5.9075514	8535.15	85.35156
7	15.438402	18.7621	6.8921433	9957.68	99.57682
8	17.643888	21.4424	7.8767352	11380.20	113.80208
9	19.849374	24.1227	8.8613271	12802.73	128.02734
10	22.054860	26.8030	9.8459190	14225.26	142.25260

UNITED STATES INTERNAL REVENUE.

REGULATIONS AND INSTRUCTIONS CONCERNING THE TAX ON DISTILLED SPIRITS.

TREASURY DEPARTMENT, OFFICE OF INTERNAL REVENUE,
Washington, April 22, 1869.

By the act of July 20, 1868 (section 1), there is laid on all distilled spirits, upon which no tax has been paid, a tax of 50 cents on every proof gallon, to be paid by the distiller, owner, or person having possession thereof, before removal from the distillery warehouse; and (section 59) an additional tax of $4 on each barrel of forty proof gallons of all distilled spirits in any bonded warehouse at the date of the taking effect of the act.

BASIS OF TAXATION.

The tax of 50 cents per gallon is to be collected on the whole number of gauge or wine gallons when the spirits are below proof, and upon the proof gallon when of greater strength than proof. The tax of $4 per barrel of 40 proof gallons is upon the proof gallons.

DISTILLER'S SPECIAL TAX.

Distillers producing 100 barrels, or less, counting 40 proof gallons to the barrel, must each pay a special tax of $400, and $4 for each barrel in excess of 100 barrels, and monthly returns of the number of barrels of distilled spirits produced must be made by each distiller as the monthly returns of sales are made.

Distillers of brandy from apples, peaches, and grapes exclusively, producing less than 150 barrels annually, are by the act of April 10, 1869, made subject to a special tax of $50, together with $4 per barrel on each barrel in excess of 100 barrels. Distillers of this class producing in excess of 150 barrels annually will be subject to the same special taxes as

other distillers. On spirits produced after July 20, 1868, the tax of $4 per barrel will be assessed monthly on Form No. 89.

There must also be assessed and collected monthly from every authorized distiller an additional tax of $2 per day, Sundays excepted, when the distillery has an aggregate capacity for mashing and fermenting 20 bushels of grain, or less, or 60 gallons of molasses, or less, in 24 hours; and a tax of $2 per day for each 20 bushels of grain or 60 gallons of molasses of said capacity, in excess of 20 bushels of grain or 60 gallons of molasses in 24 hours. But any distiller suspending work, as provided in the act, will pay only $2 per day while the work is so suspended.

TAX TO BE A LIEN.

Every proprietor or possessor of a still, distillery, or distilling apparatus is made jointly and severally liable for the taxes imposed by law on the distilled spirits produced therefrom, and the tax is a first lien on the spirits distilled, the distillery used for distilling the same, the stills, vessels, fixtures, and tools therein, and on the lot or tract of land whereon the distillery is situated, together with any building thereon, from the time said spirits are distilled until the tax is paid.

DISTILLER DEFINED.

Every person who produces distilled spirits, or who brews or makes mash, wort, or wash fit for distillation, or for the production of spirits, or who may, by any process of vaporization, separate alcoholic spirit from any fermented substance, or who, making or keeping mash, wort, or wash, has also in his possession or use a still, is, under the provisions of the law, a distiller.

MASH, WORT, OR WASH.

No mash, wort, or wash fit for distillation or the production of spirits or alcohol can lawfully be made or fermented in any building, or on any premises, other than a distillery, duly authorized according to law; and no mash, wort, or wash so made and fermented can be sold or removed from any distillery before being distilled; and no person, other than an authorized distiller, can, by distillation, or by any other process, separate the alcoholic spirits from any fermented mash, wort, or wash; and no person can use spirits or alcohol, or any vapor of alcoholic spirits, in manufacturing vinegar, or any other article, or in any process of manufacture whatever, unless the spirits or alcohol so used shall have been produced in an authorized distillery, and the tax thereon paid.

NO OTHER BUSINESS TO BE DONE IN A DISTILLERY.

The use of any still, boiler, or other vessel for the purpose of distilling, is forbidden (section 12) in any dwelling-house or shed, yard, or inclosure connected therewith, or on board of any vessel or boat, or in any building or on any premises where beer, lager beer, ale, porter, or other fermented liquors, ether, or vinegar are manufactured or produced, or sugars or syrups are refined, or liquors of any description are retailed, or *any other business is carried on*, or within 600 feet of any premises authorized to be used for rectifying. The only exceptions are the manufacture of saleratus, and the grinding of meal or flour from grain to be used only for distillation on the premises. Where there are mills attached to a distillery, they must be so entirely separated by solid walls and otherwise as to be in fact independent premises, although both establishments may be driven by the same power. They must be so arranged that the description of the distillery premises on Form No. 27 does not include the mill.

REGISTRY OF STILLS.

Every person having in his possession or custody or under his control any still or distilling apparatus set up was required to register the same with the assistant assessor of the division in which such still or distilling apparatus was located, within 60 days from July 20; and all stills thereafter set up must be registered immediately on being set up. The application for registry will be in duplicate on Form No. 26, one of which will be retained and preserved by the assistant assessor, and the other transmitted by him to the assessor of the district, and a copy thereof immediately sent by the assessor to the Commissioner of Internal Revenue. All stills and distilling apparatus set up must be registered, whether they are intended to be used or not. Each assessor will enter the registry of all stills in a book, to be kept in his office and open to inspection, denoting each distillery by its number.

ASSESSORS TO FORWARD LISTS OF STILLS, ETC.

Every assessor who has not so done, will furnish this office with a list of all stills or distilling apparatus registered in his district, giving the names of the owners, the location, and whether or not the same are intended to be used, together with the registered number of the distillery. Where the distiller is not the owner of the fee, that fact will also be stated, and whether

the consent, or stipulation, or leaseholder's bond required by section 8, has been filed with him.

DISTILLER'S NOTICE.

Every person engaged in the business of a distiller, or intending to engage therein (section 6), must give notice on Form No. 27, which is hereby prescribed, over his own signature, to the assessor of the district in which such business is, or is to be, carried on, who will furnish a copy thereof to the collector. Like notice of any change in the location, form, capacity, ownership, agency, or superintendence, or in the persons interested in the business of said distillery, or in the time of fermenting the mash or beer, is to be given within 24 hours of such change, and a copy of such notices will be immediately transmitted to the Commissioner.

NOTICES TO BE FORWARDED.

Assessors will also forward to this office information of the date when the bond was approved, if approved, and the time when the distiller commenced work; and when any distiller's bond shall be hereafter approved, notice of the date of such approval will be immediately forwarded to this office.

BONDS.

Every distiller, on filing his notice with the assessor, must, before continuing or commencing business after the passage of the act and on the first day of May in each succeeding year, make and execute a bond on Form No. 30, which is hereby prescribed, with at least two sureties to be approved by the assessor of the district. Assessors will give especial attention to the instructions printed thereon, and will require the sureties to justify on Form No. 33 in double the amount of the penal sum of the bond.

Under the provisions of section 8 no distiller's bond can be approved unless he is the owner in fee, unencumbered by any mortgage, judgment, or other lien, of the lot or tract of land on which the distillery is situated, or unless he files with the assessor, *in connection with his notice*, the written consent of the owner of the fee, and of any mortgage, judgment creditor, or other person having a lien thereon, that the premises may be used for the purpose of distilling spirits subject to the provisions of law, and expressly stipulating that the lien of the United States for taxes and penalties shall have priority of such mortgage, judgment, or other encumbrance, and that in case of the for-

feiture of the distillery premises or any part thereof, the title of the same shall vest in the United States, discharged from any such mortgage, judgment, or other encumbrance. This instrument must be duly acknowledged and executed with all the formalities required in conveyances of real estate, and must be duly recorded before the same is filed with the assessor.

As the question as to the title to the real estate is material, the assessor should require of the distiller a properly certified statement or search of the title to such estate to be exhibited to him, and full evidence as to what, if any, liens or encumbrances exist thereon.

Where the distiller's estate is for a term of years only, under a lease or other evidence of title *recorded before the passage of the act, the distillery or distilling apparatus having also been erected prior to that date*, the distiller may, in lieu of the consent and stipulation aforesaid, give an additional bond on Form No. 3, which is hereby prescribed, with not less than two sureties, residents of the district or county or an adjoining county, and owners of unencumbered real estate in said district or county equal to the penal sum of the bond. In such case the assessor will cause the value of the lot or tract of land, together with the buildings and distilling apparatus, to be appraised by two or more competent persons, to be designated by him, and the said appraisal may be increased by the assessor if, in his judgment, the same is too low, and the penal sum of said bond must be equal to such appraised value. This is in addition to the distiller's bond required by section 7, and a substitute for the ownership in fee of the distillery premises; and if the same sureties should be offered upon both bonds, the assessor will see that they are the owners of unencumbered real estate, as aforesaid, sufficient in value to cover their liability upon both bonds. No assessor will (section 17) approve the bond of any distiller until all the requirements of law and the regulations in relation to distilleries have been complied with.

No distiller's bond should be approved until his distillery warehouse has been approved and established under the act of July 20, 1868, and a storekeeper assigned thereto by the Commissioner of Internal Revenue.

The bonds of distillers, when approved by the assessor, will be filed with the collector of the district. Where the distiller is not the owner in fee of the distillery premises, assessors must require a strict compliance with the provisions of section 8.

Under the provisions of the amendatory act of April 10, 1869, a bond of the character of leaseholder's bond may, at the discretion of the Commissioner, be taken where the lease or title was

not required by the laws of the State to be recorded, in order to render it valid, or where the title was on July 20, 1868, and has continued to be, in litigation; or where there was a mortgage duly recorded prior to that date, which is not due; or where the fee is held by a *feme covert*, minor, person of unsound mind, or other person incapable of giving consent as required in section 8. But none of these provisions apply to a case where the distillery and distilling apparatus was not erected prior to July 20, 1868.

Any person desiring to avail himself of this provision must make application to the Commissioner, showing, in case of a lease, that there was a valid subsisting lease on or before July 20, 1868, under which he holds, and that the same was not required to be recorded by the laws of the State; if the title is in litigation, in what court the proceedings are pending; the parties thereto and the nature of their claims, and that such litigation was pending July 20, 1868; if a mortgage, the date and amount of the same, when recorded, by whom held, and when the same is due; and in case of incapacity to consent, the nature of said incapacity. In all cases a full and clear statement of the title to the estate should be given, and such application should have indorsed thereon the certificate of the assessor of the district that he has personally investigated the case, and finds that the statements made are correct.

PLAN OF DISTILLERY.

Previous to the approval of his bond, every person intending to engage in the business of a distiller must, under the direction of the assessor, cause to be made an accurate plan and description in triplicate of the distillery and distilling apparatus, as provided in section 9. *Such plan must be on good paper or tracing cloth, fifteen by twenty inches in size, with a margin of at least one inch on each side of the drawing;* and where the distillery or distilling apparatus occupies more than one floor or story, each floor or story should be represented on a separate sheet. The assessor must, by personal examination, test the accuracy of such plan when made, and none but competent draughtsmen should be employed to make it. The capacity of each tub or vessel should be marked on the plan in gallons.

After such plan is made, no alteration can be made in such distillery or distilling apparatus without the written consent of the assessor, and such alteration must be shown by a supplemental plan and description, which should also be made in triplicate like the original. One of said plans is to be kept displayed in some conspicuous place in the distillery, one kept by

the assessor, and one transmitted by him to the Commissioner of Internal Revenue, *rolled and not folded;* and any supplemental plan will be disposed of in the same manner. The accuracy of every plan must be verified by the assessor, the draughtsman, and the distiller; and the assessor will note a reference to such supplemental plan on the copy in his possession, and on that of the distiller, and send a copy of such memorandum, with such supplemental plan, to the Commissioner.

NOTICE OF INCREASE OF CAPACITY.

In case a distiller desires to increase his capacity after his plans are furnished, the survey made, and his bond is approved, he must give notice under section 6, and if such change necessitates any alteration in his distillery, as the introduction of additional mash or fermenting tubs, a supplemental plan must be furnished showing the alterations. If such alterations are confined to one floor, a supplemental plan of that floor, properly certified, will be received.

ASSESSORS TO REPORT REDUCTION, ETC.

Where the capacity is reduced, as provided in section 30, the assessor will make an immediate report of the facts to this office, designating the tubs which are closed or sealed up by their numbers as shown upon the plan on file, stating also the deduction necessary to be made in the survey; and when the fastenings of these tubs are removed, a like report should be made, in all cases giving the dates when such changes are made.

SURVEY.

The survey required by section 10 is to be made of every distillery registered, or intended to be registered, for the production of spirits, and of every still or distilling apparatus hereafter set up. The object is to determine the true producing capacity of each distillery, *i. e.*, the quantity of spirits which may be produced in such distillery in twenty-four hours. In addition to this, the report should state the aggregate mashing and fermenting capacity in bushels or gallons, *i. e.*, the number of bushels of grain or gallons of molasses which may be mashed and fermented in twenty-four hours. As this is one of the tests by which the amount of tax due is to be determined, it should be carefully and correctly made. The report should be immediately forwarded to the Commissioner, who, if he shall at any time be satisfied that it is incorrect or needs revision, may direct a new survey to be made.

INSTRUCTIONS AS TO SURVEY OF DISTILLERIES.

In their report of the survey, assessors will state the greatest and least diameter, and the depth of each mash-tub, its full capacity, the number of dry inches allowed for working, and the working capacity in bushels, estimating not exceeding 30 gallons to the bushel.

They will also give the greatest diameter, least diameter, and depth of each fermenting tub, designating the same by its number as shown by the plan, with the full capacity, the number of dry inches allowed for fermentation, and the working capacity of each tub.

Having found the aggregate working capacity of the fermenters, they will divide this amount by the number of gallons of mash which the distiller makes from a bushel of grain (not exceeding, however, 45 gallons of mash to the bushel of grain in any case), which will give the number of bushels that will be required to fill the fermenters. Then, taking the fermenting period as fixed by the distiller on Form No. 27, or the average fermenting period actually used by the distiller as ascertained by the assessor and the person designated to aid him, from the best evidence accessible to them, which must be a fixed and definite number of hours or days, adding thereto 24 hours or one day for the time each fermenter is required to remain empty after its contents are drawn off, and dividing the number of bushels by this sum, the result will be the number of bushels which can be fermented in 24 hours. If not even days, divide by the number of hours and multiply by 24.

They will then estimate the quantity of spirits which can be produced from a bushel of grain. This depends in a great degree upon the character and completeness of the apparatus; and while no fixed rule can be laid down upon this point, it may be suggested that in an ordinary steam distillery this varies from three to four gallons, many distilleries producing 15 and 16 quarts to the bushel. It would require a strong case to justify an estimate as low as three gallons, and in such case the reasons for such allowance must be fully reported to the Commissioner. In all cases it should be assumed that the distiller will have his apparatus in good order and use good material. Having determined this product, multiply the number of bushels that can be fermented in 24 hours by this sum, and it will give the quantity of spirits which can be produced in 24 hours.

The capacity of a molasses distillery is estimated upon the same principle. Having found the working fermenting capacity of the fermenters in gallons, as above stated, divide this by the number of gallons of mash which the distiller makes from a

gallon of molasses, not exceeding seven gallons of mash for a gallon of molasses, and it will give the number of gallons of molasses required to fill the fermenters. Take the fermenting period, plus the 24 hours, and divide the amount found as above, and it will give the quantity which can be fermented in 24 hours.

The quantity of spirit which can be produced from a gallon of molasses varies, of course, with the completeness of the apparatus and the quality of the material, from 80 to 95 per cent.—from 85 to 90 per cent. probably being a fair average; and in no case should a less allowance than this average be made without first submitting a full report of the reasons therefor to the Commissioner.

In case any question arises as to the correctness of the survey, the assessor will forward a draft of his report to the Commissioner before it is signed, in order that such questions may be determined.

In estimating the number of dry inches to be allowed for fermentation, the assessor and person designated to aid him must, of course, be governed in a great measure by the depth of the fermenting tubs. From the best information received, it is believed that a fair allowance will be from three to seven dry inches for corn, and any mixture of corn and rye not exceeding one-half rye to one-half corn; and from seven to twelve dry inches for rye, and any mixture of rye exceeding one-half. While it is perhaps natural that the distiller should claim the maximum allowance as most advantageous to him, it is incumbent upon the officers making the survey to make such allowance only as is fair and equitable, having regard to the interests of the government as well as of the distiller. Should the allowances in any district in all cases equal the maximum allowance, or in most cases exceed the average between the two extremes given, the survey should be accompanied by some explanation of the reasons therefor to rebut the inference which might be drawn from such action.

CONSTRUCTION OF DISTILLERIES.

The door of the furnace of every still or boiler used in any distillery (section 17) must be so constructed that it may be securely fastened and locked. This must be so done that the government locks may be applied, and so as to effectually prevent the doors from being opened, or the fires lighted in the furnace when locked.

The fermenting tubs must be so placed as to be easily accessible to any officer, and must each have painted thereon in oil

colors its cubic contents in gallons, with the number of the tub, which should correspond with that given in the notice and on the plan. There must be a clear space of not less than one foot around every wood still, and not less than two feet around every doubler and worm tank. The doubler and worm tanks are to be elevated not less than one foot from the floor. Every fixed pipe, except those used only for the conveyance of water or of spent mash or beer, must be so placed as to be capable of being examined for its whole length, and must be painted and kept painted as follows: Pipes for the conveyance of mash or beer, of a red color; for the conveyance of low wines back into still or doubler, blue; for the conveyance of spirits, black; for the conveyance of water, white; and they must be designated by those colors on the plan.

LOCKS AND SEALS.

All locks and seals required by law will be designated by the Commissioner of Internal Revenue, and are to be procured of the collector of the proper district, at the expense of the distiller, except the locks for the closing of the doors of the furnaces of the stills and boilers, which will be furnished to the assessors.

RECEIVING CISTERNS.

Every distiller (section 16) is required to erect two or more receiving cisterns in a room or building used for that purpose, and for no other, for each distillery. Each of these cisterns must be of sufficient capacity to hold all the spirits distilled during the day of 24 hours. These cisterns must be so constructed as to leave an open space of at least three feet between the top and the roof or floor above, and a space of not less than 18 inches between the bottom and the floor below, and they must be separated so that the officer may pass around them; and the pipes or other apparatus by which the cisterns are connected with the outlet of the stills, boilers, or other vessels, must be so constructed as to be always exposed to the view of the officer, and so as to prevent the abstraction of spirits while passing from the outlet of the worm or condenser back to the still or doubler or forward to the receiving cistern. These cisterns must not be connected with each other. Where a distiller draws off his spirits but once in three days, he must have three cisterns. He cannot, in any case, have less than two. The product of each day's distillation must be run into one cistern, and one only. If the distiller has not provided at least two separate cisterns, each of a capacity sufficient to hold

a full day's product, the assessor has no right to approve his bond; if he does so, he renders himself liable to the penalty imposed in section 17.

SIGNS, FENCES, AND GATES.

Every person engaged in distilling or rectifying spirits, and every wholesale liquor dealer, is required (section 18) to place, and keep conspicuously on the outside of his distillery, rectifying establishment, or place of business, a sign, in plain and legible letters not less than three inches in length, painted in oil colors or gilded, and of a proper and proportionate width, the name or firm of the distiller, rectifier, or wholesale dealer, with the words "registered distillery," "rectifier of spirits," or "wholesale liquor dealer," as the case may be. No fence or wall of a height greater than five feet can be allowed around the premises of any distillery so as to prevent easy and immediate access thereto. Every distiller must furnish to the assessor of the district as many keys to the doors and gates of the distillery as may be required by the assessor from time to time; and the distillery must always be kept accessible to any officer or other person having such key.

COMMENCEMENT OF WORK.

Section 22 provides that every distiller, at the hour of 12, meridian, on the third day after that on which his bond is approved by the assessor, shall be deemed to have commenced, and thereafter to be continuously engaged in, the production of distilled spirits in his distillery, except during the time when work shall be suspended in accordance with the provisions of that section.

This gives the distiller the three days in which to prepare his first mash for distillation, and as he cannot (section 21) do this in the absence of the storekeeper, assessors should withhold the formal approval of the bond until notified that his warehouse is established and a storekeeper assigned.

WHEN CAPACITY-TAX TO COMMENCE.

The per diem capacity-tax imposed by section 13 will commence on the third day after the approval of the bond, and the full capacity-tax provided for in that section will be assessed for every calendar day thereafter, Sundays excepted, reckoning the third day after the approval of the bond as a whole day, unless work shall be suspended as provided in section 22.

But should the distiller commence distilling at any time prior

to the third day after the approval of the bond, the capacity-tax will be assessed from the time when the production of spirits begins.

SUNDAYS.

No malt, corn, grain, or other material (section 35) can lawfully be mashed, nor any wash, wort, or beer brewed or made, nor any still used by a distiller at any time between the hour of 11 in the afternoon of Saturday and 1 in the forenoon of the next succeeding Monday, under penalty of one thousand dollars for each offence

CAPACITY, REDUCTION OF.

Any distiller desiring to reduce the producing capacity of his distillery must give notice of such intention in writing to the assessor, stating the quantity of spirits which he desires thereafter to manufacture every 24 hours; and thereupon the assessor is required, at the expense of the distiller, to reduce and limit the producing capacity of the distillery to the quantity stated in his notice, by placing upon a sufficient number of tubs close-fitting covers, securely fastened by nails, seals, and otherwise, so as to prevent the use of such tubs without removing said covers or breaking said seals; and whenever he shall be of opinion that other precautions are necessary, he will report the case to the Commissioner of Internal Revenue for instructions. Where a distiller desires to reduce his capacity without reducing the number of his tubs, it can only be done by cutting down the tubs to the size required. The mere cutting out of one or more staves is not sufficient, but the whole tub must be cut off.

In all cases of a reduction of capacity an immediate report will be made to the Commissioner by the assessor, showing what action has been taken and the proportionate reduction of capacity thereby effected.

OFFICERS' RIGHT OF ENTRY.

Any revenue officer (section 32) may at all times, as well by night as by day, enter any distillery or building or place used for the business of distilling, or in connection therewith for storage or other purposes; and if not admitted upon demand, having declared his name and office, he may break open any doors or windows, or break through any of the walls of such premises necessary to be broken to enable him to enter. Any officer (section 31) may require the water in any worm tub to be drawn off and the tub and worm cleansed at any time when

the still is not at work, and the water must be kept out of the worm tub for two hours, or until the officer has finished his examination.

SUSPENDING WORK.

Any distiller desiring to suspend work (section 22) must give notice in writing to the assistant assessor, stating when he will suspend work. On the day mentioned, the assistant assessor will, at the expense of the distiller, proceed to fasten securely every door of every furnace, still, or boiler in said distillery, by securely locking the same, so that they cannot be opened or any fire lighted in such furnace. Such notice must be immediately reported to the assessor, and also the action taken thereon, and such notice and report must be transmitted to the Commissioner of Internal Revenue. No distiller can carry on the business of a distiller after the time stated in such notice until he shall have given another notice in writing to the assessor stating the time when he will resume work, at which time the assistant assessor must attend and remove the locks and other fastenings, which action must be immediately reported to the assessor and by him to the Commissioner, and the report of the assistant assessor must distinctly state whether or not there was any mash, wort, or beer on hand at the time of such suspension.

WHEN DEDUCTIONS ALLOWED.

No deduction is to be made for a suspension of work unless the provisions of section 22 are strictly complied with. The distiller must give two notices in writing to the assistant assessor, first, of the time when he proposes to suspend work, and, second, a like notice of the time when he proposes to commence; at both of which times the assistant assessor must be present to secure the furnaces or to remove the fastenings, as the case may be, and these two notices cannot be combined in one.

Attention is called to the provision of this section imposing penalties upon any distiller who, after the time fixed in his notice of intention to suspend work, shall carry on the business of a distiller on said premises, or shall have mash, wort, or beer in his distillery or on any premises connected therewith, or who shall have in his possession or under his control any mash, wort, or beer, with intent to distill the same on said premises. Unless the distiller chooses to destroy the mash on hand when he suspends work, he must fix his time so that he will have time to run off the mash on hand before the notice takes effect, as after the time stated he can have no mash, wort, or beer on his distillery premises. If he does the business of a distiller on the

premises, or has any mash, &c., therein, or in his possession or under his control, with intent to distill the same therein, he cannot suspend work under that section, and is not entitled to any deduction of the per diem capacity-tax. The attention of assessors is especially called to this matter.

FERMENTING TUBS TO BE EMPTIED.

At the end of the fermenting period every fermenting tub must be emptied and remain empty twenty-four hours.

DATE OF EMPTYING THE TUBS.

Under the heading "fermenting tub emptied of beer or mash," on Form No. 100, the storekeeper will enter in the proper column the number of the tub on the line opposite the proper date entered in the left-hand column. If four tubs are emptied on the same day and but three lines are used for the description of the materials used, as corn, rye, malt, then one line should be left blank in this column on the day named. It is highly important that the day, as well as the hour of the day in which each tub is emptied, should be accurately stated.

SPIRITS TO PASS DIRECTLY FROM STILL TO RECEIVING CISTERN.

The storekeeper will see that all spirits manufactured each day are conveyed into one of the receiving cisterns on the same day. The cisterns and the room in which they are contained must be in charge of and under the lock of the internal revenue gauger designated for that duty. The collector will designate the gauger to perform this duty. The supervisor, however, has power to transfer gaugers so designated from one distillery to another. In no case, however, will the storekeeper be allowed to hold the key or have charge of the cistern-room. The cistern-room must not be opened or suffered to remain open except when the designated gauger is present, nor will the key of the government at any time be suffered to pass into the possession of the distiller or any person in his employ. Until locks are prescribed, collectors and assessors will require such to be provided as in their judgment may be appropriate.

GAUGING, MARKING, AND STAMPING.

When drawn into casks, the spirits must be gauged and proved by the gauger himself, with his own hands, and in no case can he deputize another person to do it for him. When gauged and proved, the gauger will mark with a cutting or branding iron upon the bung stave of each cask the number of

wine gallons and the number of proof gallons contained therein, with the proof, and the gauger will, in the presence of the store-keeper, place upon the head of each cask the distillery warehouse stamp, and also cut or burn upon the head of each barrel the serial number of the barrel.

The serial number for every distillery must begin with number one (No. 1) with the first cask deposited, and continue the series until the last day of the year, commencing a new series on the first day of January in each year thereafter ; and no two or more casks warehoused at the same distillery may be marked with the same number.

NO ALLOWANCE TO BE MADE FOR LOSS BY LEAKAGE OR OTHERWISE.

Section 23 of the act of July 20, 1868, requires that all distilled spirits shall be drawn from the receiving cisterns into casks, which, after being marked and stamped in such a way as to show the contents, are to be immediately removed into the distillery warehouse. On the prescribed days, to wit, the first, eleventh, and twenty-first days of each month, the distiller must make his "entry for deposit," which must cover all the spirits stored or deposited during the preceding tri-monthly period, and must specify the number of wine and proof gallons contained in each of the casks so deposited, and the amount of tax on the spirits. At the same time the distiller is required to give his bond (on Form No. 80), conditioned that *he will pay the tax on the spirits as specified in the entry*, or cause the same to be paid *before removal* from said distillery warehouse, and *within one year from the date* of said bond.

Under this language it is very plain that no allowance can be made for any loss occurring in warehouse from leakage or any other cause.

The amount of tax named in the entry and secured by the bond must be paid within the time named, even though loss may occur by leakage, by fire, or otherwise. In this regard spirits stored in warehouse are placed on the same footing with tax-paid spirits. The primary object of the present law was to collect the tax on all the spirits produced and drawn from the cistern, and the privilege of storing in warehouse for one year or less was not intended to and does not carry with it any advantage, in respect to loss, not conceded to the distiller who pays the tax on the same day that the spirits are drawn from the cistern.

Such being the law, it is obvious that spirits in distillery warehouse are not required to be gauged and proved before

withdrawal therefrom, nor before the entry for withdrawal is made. The "entry for withdrawal" must correspond precisely to the "entry for deposit;" the tax-paid stamp must specify the amount of tax on the same number of gallons as are named on the distillery warehouse stamp, and this amount must be paid before withdrawal. The collector, instead of directing the gauger to gauge and inspect spirits in warehouse *before* the "entry for withdrawal" is made, will, upon receiving the entry made as above set forth, direct the gauger to proceed to the warehouse, and there, in presence of the storekeeper, stamp and mark the casks as required by law and regulation.

THE TAX ON ALLOWANCES HERETOFORE MADE MUST BE COLLECTED.

The rule laid down on page 17 of Instructions, Series 4, No. 1, providing for an allowance for loss by leakage in warehouse, has been revoked. In any case where this rule has been applied to spirits produced since July 20, 1868, the collector is hereby instructed to collect, without delay, all sums which have been so allowed for loss by leakage or otherwise. The law is explicit and imperative, and as it gives no discretion to the Commissioner or to any other officer to modify its operation in this respect, appeals to him for this purpose are useless. The bonds given under section 23 (on Form No. 80) must be held for the payment of all such allowances, and, if necessary, must be put in suit to recover the same.

In cases where spirits were withdrawn before the end of the tri-monthly period, and for that reason no bond was given for the tax on such spirits, the tax must be collected on all allowances made for loss while in warehouse.

FRACTIONS OF GALLONS.

The law requires "the quantity in wine gallons and in proof gallons of the contents of each cask" to be marked upon the cask, reported by the gauger, &c. Consequently the exact number of gallons must be ascertained, marked, and reported. Fractions of gallons must be indicated in all cases, but the tax will be collected on the fraction of the gallon as if it were a whole gallon. A fraction of a wine gallon, however, is not to be taken as a whole gallon in calculating the number of proof gallons in a cask.

WANTAGE.

The rule printed on pages 6 and 7 of Instructions, Series 2, No. 11, in regard to wantage, will be applied to the gauging and

proving of spirits at the distillery before storage in warehouse, viz: No larger allowance for wantage than a half *wine* gallon for each cask or barrel will be made, unless ascertained by measurement with the wantage-rod. When the wantage is found by actual measurement to exceed a half gallon, the actual wantage will be allowed, and no more.

DISTILLER TO PROVIDE WAREHOUSE.

Every distiller must provide, at his own expense, a warehouse suitable for the storage of distilled spirits, which must be situated on and constitute a part of his distillery premises. No dwelling-house can be used for such purpose; and no door, window, or other opening can be made or permitted in the walls of such warehouse leading into the distillery, or into any other room or building. No spirits can be stored in such distillery except those manufactured by the distiller providing it. A portion of the distillery may be used for this purpose, but in such case it must be separated from the distillery by a solid brick or plank partition; and collectors will, when such warehouse is applied for, make careful examination as to the sufficiency of the division walls; but the entrance to such room must be from the street or yard. If the distiller elects, such warehouse may be a separate building, but it must be upon the premises actually occupied for the distillery. It must be a portion of the distillery, adjoining the distillery building, or within or adjoining the distillery yard.

Every distiller will make application in writing to the collector of the district, stating fully the precise location, size, description, and construction of the room or building desired for such warehouse, specifying its location upon or by reference to the plan of the distillery; and upon receipt of such application the collector will, by himself or one of his deputies, make a full and careful examination thereof, and if the same is approved by him, will transmit said application to the Commissioner of Internal Revenue, with his report thereon, for his approval, stating the estimated storage capacity of such warehouse; and when approved by the Commissioner, a storekeeper will be assigned to such warehouse. Such warehouse must be established for each distillery before any spirits are distilled, and all expenses connected with such warehouse must be paid by the distiller.

STOREKEEPERS.

Storekeepers are appointed by the Secretary of the Treasury (section 52), one or more of whom will be assigned by the

Commissioner of Internal Revenue to every warehouse. The storekeeper assigned to any distillery warehouse will (section 21) also have charge of the distillery connected therewith.

Supervisors have authority to transfer storekeepers from one distillery warehouse to another, *i. e.*, to change their location after they have been assigned; but they cannot relieve a storekeeper from duty except by suspending him from office. All charges made by supervisors must be immediately reported to the Commissioner, and unless the case is one requiring immediate action all changes should be made by reassignment from the Commissioner.

Storekeepers cannot engage in any other business while in the service of the United States, without the written permission of the Commissioner of Internal Revenue. In case of the temporary absence of the storekeeper from sickness or other cause, the collector having control of the warehouse may designate some person to have temporary charge of such warehouse, who will have all the powers and be subject to all the liabilities of a storekeeper while so acting.

Collectors, however, have no power to designate a person to act as storekeeper at a warehouse to which no assignment has been made by the Commissioner. Their power is limited to supplying the temporary absence of the regularly assigned storekeeper. An absence occasioned by a removal from office, or suspension, or revocation of the assignment, is not a temporary absence.

The storekeeper will keep the warehouse book on Form No. 101, and make daily returns in duplicate (section 52) to the collector and Commissioner, and triplicate monthly reports to the Commissioner, the assessor, and collector; and, as having charge of the distillery, will also keep the book required by section 21, on Form No. 100. The books must be furnished to the storekeeper by the distiller.

MASHING, DISTILLING, AND REMOVAL OF SPIRITS PROHIBITED IN THE ABSENCE OF STOREKEEPER.

The special attention of officers and distillers is directed to the penalties imposed in section 21 for mashing, distilling, or removing spirits in the absence of the storekeeper or person designated to act as storekeeper. Any mashing or distilling done at night, or at any other time when the storekeeper is not present, is prohibited. It is the duty of all officers, and especially of collectors, to see that this law is obeyed, and its violation noted and properly punished.

COMPENSATION OF STOREKEEPERS.

Storekeepers are not entitled to compensation until assigned to duty at a warehouse by the Commissioner of Internal Revenue. After such assignment they will be entitled to the rate of compensation fixed in their assignment for the time during which they are actually employed. Where, during the temporary absence of the regular storekeeper, the collector designates some person to act for him, the person so designated will be entitled to the same rate of compensation as the regular storekeeper for the time he is so employed, and the regular storekeeper will not be entitled to compensation for such time. In order to entitle a storekeeper to compensation he must have been assigned to the warehouse by the Commissioner, or transferred thereto by the supervisor, and have actually performed his duties as such during the time for which compensation is claimed.

The provision forbidding storekeepers to engage in any other business does not apply to a storekeeper who is not under actual assignment to duty.

Whenever work is suspended or resumed in a distillery, the assessor will notify the storekeeper; and where such suspension is for an indefinite time, or for a period exceeding one week, the assessor will immediately report the fact to this office, and whether or not the services of the storekeeper can be dispensed with. This is not to be included in or to take the place of the report of the notice of suspension or resumption of work, but a separate report.

REIMBURSEMENTS BY THE PROPRIETORS OF INTERNAL REVENUE BONDED WAREHOUSES OF THE EXPENSES AND SALARIES OF STOREKEEPERS.

Public resolution No. 5, approved March 29, 1869, to supply omissions in enrolment of act approved March 3, 1869, provides, "that after the passage of this act the proprietors of all internal revenue bonded warehouses shall reimburse to the United States the expenses and salary of all storekeepers or other officers in charge of such warehouses, and the same shall be paid into the treasury and accounted for like other public moneys."

To carry the foregoing provision of law into practical effect, collectors are hereby instructed to demand and collect monthly hereafter, commencing with the 4th of March, 1869, from owners of bonded warehouses situated in their districts, such sums as may have been paid to United States "storekeepers or

other officers in charge of such warehouses" for salary and other expenses, and to deposit the same to the credit of the Treasurer of the United States, in the same manner that other public moneys are now required to be deposited, as a reimbursement of the "appropriation for salaries of collectors, assessors, &c. of internal revenue," which appropriation should be named on the face of the certificate of deposit. The certificate of the assistant treasurer or designated depositary, as the case may be, will be taken in triplicate, the original of which will be forwarded direct to the Secretary of the Treasury, the duplicate filed in this office with Special Account Current No. 119, and the triplicate retained for their own protection.

Hereafter, in making payments to storekeepers, collectors will require them to sign triplicate vouchers, the original and duplicate to be disposed of as required by existing regulations, and the triplicate to be presented to the owner of the bonded warehouse, with demand for reimbursement, and surrendered and receipted in his favor by the disbursing agent, when the amount thereof shall have been reimbursed to the United States. The amount of the reimbursement thus made will be entered to the credit of the United States in a separate account current upon Form No. 119, which, with its appropriate abstract, No. 120, will be furnished from this office. This account current will be supported by the duplicate certificate of deposit referred to above, and will be mailed to this office within fifteen days after the close of the month in which the reimbursement and deposit may have been made. The first account current under these instructions will be rendered for the month of April present, and will include all reimbursements of salary and expenses paid to storekeepers from and after the 4th of March (the date when the law took effect) to the 30th of April, 1869.

STOREKEEPERS' REPORTS.

The storekeeper's daily report is to be made, whether any entries are made upon his warehouse book or not, during all the time he is in charge of the distillery warehouse. If no spirits are deposited or withdrawn, the report should so state. Storekeepers will enter upon the warehouse book the number of packages deposited, the serial numbers of the casks, the serial numbers of the warehouse stamps, and the actual quantity in wine and proof gallons—in gallons and fractions of gallons. In the entries for withdrawal the serial numbers of casks and stamps and the quantity must correspond with the entries for deposit. Fractions of gallons are in no case to be entered upon the books as whole gallons; neither must tax-paid stamps be

reported or entered in any instance. Fractions of gallons are treated as whole gallons only in determining the amount of tax due upon the quantity in a given package. The daily reports must be a correct copy of the entries upon the warehouse book for the day, and the monthly report the aggregate footings for the month.

In making their monthly abstracts, Form No. 88, they will enter first the amount of mash on hand at the close of the preceding month. Under this they will enter the quantity of material used during the month, with the quantity of mash produced therefrom, and from the amount of these two items deduct the quantity of mash on hand at the end of the month.

All spirits should be drawn from the receiving cisterns after distillation ceases on the last day of the month, or on the morning of the first day of the month, so that the full product of the month may be known and determined. If drawn off on the first day of the month, the quantity drawn off and warehoused on that day will be entered on the distiller's tri-monthly—the storekeeper's abstract, Form No. 88, and on Form No. 89—in a separate item.

It is the duty of the storekeeper to know that all entries and reports made by him are correct. He has no right to estimate or to trust to information received from the distiller or any person in his employ. He is placed on duty, not to receive and record the reports of the distiller or his employés, but to keep a record of transactions of which he is required to have a personal knowledge. The quantity of mash in a tub at the time it is emptied is not the subject of an estimate, but is to be determined by actual measurement; and the quantity made and used during the month, or on hand at its close, can and must be determined in the same way.

The attention of storekeepers and other officers is specially called to these instructions, as the reports heretofore made are generally erroneous in some one or more of these particulars. Perfect accuracy must be the standard, and constantly recurring defects or negligence or carelessness in making their reports will be deemed sufficient cause for removal.

If there is any violation of law or irregularity on the part of the distiller, the storekeeper must make immediate report of the same to the collector and to the Commissioner, and for any neglect to do so he will be dismissed. Where a distillery is closed on account of any violation of law which is reported by the storekeeper, such storekeeper will be promptly assigned to another warehouse.

ENTRY FOR WAREHOUSING.

All spirits when drawn from the receiving cisterns must be immediately removed to the distillery warehouse, and on the first, eleventh, and twenty-first days of each month, or within five days thereafter, the distiller or owner must enter the same with the collector of the district for deposit in such warehouse. The entry must be made and signed by the distiller or owner of the spirits in the following form:—

ENTRY FOR DEPOSIT IN DISTILLERY WAREHOUSE.

Entry of distilled spirits deposited by ——— ——— in distillery warehouse No. — in the ——— district, State of ————, during the ten days ending on the —— day of ——, A. D. 186–, distilled by ——— ———.

Kind of spirits.	Date of deposit.	Number of casks.	Wine gallons.	Proof gallons.	Serial numbers, casks.	Serial numbers, stamps.	Amount of tax.

Dated at ———, ———, 186–.

(Signed) ——— ———.

State of ———, *County of* ———, *ss:*

Personally appearing ——— ———, made oath that the foregoing statement by him subscribed is in all respects correct and true.

Before me,

——— ———,

Collector ——— district ———.

Dated ———, ———, 186–.

The entry will be made in triplicate, one to be retained by the collector, one sent with the duplicate of the bond to the Commissioner of Internal Revenue, and the other sent to the storekeeper in charge of the warehouse; and at the time of making said entry the distiller will give bond in duplicate on Form No. 80, which is hereby prescribed.

Entries for deposit are to be made tri-monthly only, and such entry must cover the total amount of spirits deposited during the entire tri-monthly period next preceding the entry, and no entry for deposit can be made except as herein prescribed.

WITHDRAWAL OF SPIRITS FROM WAREHOUSE.

Spirits may be withdrawn from warehouse on payment of the tax on making with the collector of the district an entry for withdrawal in duplicate, as follows:—

ENTRY FOR WITHDRAWAL OF SPIRITS FROM WAREHOUSE—TAX PAID.

Entry of distilled spirits to be withdrawn on payment of tax from distillery warehouse No. ——, by ——— ———. Entered for deposit on the —— day of ———, A. D. 186–, by ——— ———, in said warehouse.

Kind of spirits.	Number of casks.	Wine gallons.	Proof gallons.	Serial numbers, barrels.	Serial numbers, stamps.	Amount of tax.	For what purpose withdrawn.

Dated at ———, ———, 186–.

(Signed) ——— ———.

STATE OF ———, *County of* ———, *ss:*

Personally appearing ——— ———, made oath that the foregoing statement by him subscribed is in all respects correct and true.

Before me,

——— ———,

Collector ——— district.

Dated ——— —, A. D. 186–.

On the payment of the tax, the collector will indorse upon the back of a copy of said entry an order to the storekeeper in charge of the warehouse, for the delivery of the spirits specified in the entry, in the following form, viz:—

OFFICE OF COLLECTOR OF INTERNAL REVENUE,
——— District of the State of ———, 186–.

SIR: The full amount of taxes due and owing on the distilled spirits described in the within entry of withdrawal having this day been paid to me, you are hereby directed to deliver said spirits to Mr. ——— ———, after this order shall have been countersigned by the assessor of this district, or the assistant assessor, as directed by regulation.

(Signed) ——— ———,
Collector.

To Mr. ——— ———,
Storekeeper.

This order will be countersigned by the proper assessor, or assistant assessor, in the following form, viz:—

I hereby certify that the foregoing order has been presented to me, and that the amount of taxes certified therein to have been received has been entered in the bonded account of this district, kept in my office.

(Signed) ——— ———,
Assessor.

This order must be presented to and signed only by the assessor, in all city districts, as well as in all other districts where the warehouse from which the goods are withdrawn is situated in the same place or town with the assessor's office, or is within a convenient distance therefrom. In other districts the certificate may be signed by the assistant assessor of the division in which the warehouse is situated; and in such case he must immediately make an entry upon the assessment book of the items stated in the permit, and transmit to his assessor a duplicate of the entry, or a statement showing date, names, article, quantity, and amount of tax, as given in the entry.

The collector will place one of said entries on file in his office, and transmit the other to the Commissioner of Internal Revenue.

Entries for withdrawal may be made at any time after the spirits have been stored in the warehouse, and entered upon the bonded account. All the spirits produced in any distillery must be removed to the distillery warehouse, even when they are immediately withdrawn therefrom on the payment of the tax; and the entry for deposit must be made at the regular tri-monthly periods, although the spirits covered by it have been withdrawn. The bond to be given must cover all the spirits remaining in warehouse at the end of the tri-monthly period. If all the spirits deposited during that period have been withdrawn, no bond will be required; but the collector will, in such case, certify upon the entry that such spirits have been withdrawn upon the payment of the tax, giving the dates of the withdrawals, and the amount of the tax collected on each. When a portion only of the spirits deposited during the tri-monthly period is withdrawn prior to the entry for deposit, the bond will be taken for the

quantity remaining in warehouse at the end of the tri-monthly period, and the collector will make a like certificate covering the quantity withdrawn.

BONDS AND WITHDRAWAL ENTRIES TO BE STAMPED.

All warehousing bonds must be properly stamped, and the duplicate must be stamped as an original bond. Every entry for withdrawal (original and duplicate) must have affixed a 50-cent internal revenue stamp.

THE BONDED ACCOUNT.

The bonded account will be kept and reported as heretofore directed in Series 3, No. 9, pages 70 and 71, until otherwise ordered.

FILLING UP WHILE IN BOND ILLEGAL.

If the question had not been frequently asked whether casks of spirits in distillery warehouses cannot be filled up before withdrawal, with spirits taken directly from the cistern, it would scarcely be necessary to state that such filling up is contrary to law, and whoever does, permits, or connives at the act, is guilty of a fraud upon the government.

PAYMENT OF TAX WITHIN ONE YEAR.

As the law requires the tax to be paid within one year from the date of the bond, collectors are cautioned to keep the entries, accounts, and dates in such manner that the specified lots covered by each bond can be readily identified, and this provision of law promptly enforced. It is hardly necessary to add that this provision applies exclusively to distilled spirits produced *since* July 20, 1868.

CUSTODY OF WAREHOUSE.

The storekeeper will have charge of the warehouse to which he may be assigned, under direction of the collector controlling the same. The warehouse will be in the joint custody of the storekeeper and the proprietor thereof, and kept securely locked. The storekeeper will retain the key of the government lock, and will not permit the same at any time to go into the possession of such proprietor, and the warehouse must at no time be unlocked or remain open unless in the presence of the storekeeper.

GAUGERS.

One or more internal revenue gaugers will be appointed (section 53) in every district where it may be necessary, who are to be sworn and give bond in not less than five thousand dollars, for the faithful discharge of their duties. Gaugers will inspect, brand, and stamp all spirits required by law to be inspected, and all spirits which have been inspected, when directed so to do by the collector. No gauger can be appointed a storekeeper, nor can he deputize or allow another person to act for him. Returns of inspections are to be made daily, in duplicate, to the assessor and collector, containing a true account, in detail, on Form No. 59.

GAUGERS' FEES.

The fees for gauging are to be collected by the collector of the district, and on the first day of each month he will pay to each gauger the amount of fees due him for the work done during the preceding month, not exceeding, however, $250 in any month. The accounts of the gaugers are to be settled and closed monthly. It was not intended that money earned by one gauger should be given to another who did not earn so much; nor, if a gauger's fees amount to more than $250 in any one month, can the balance be carried forward and paid to him in any succeeding month, when the aggregate fees for the month do not amount to that sum.

Under the clause in section 53, providing that fees for gauging shall be prescribed by the Commissioner, "to be paid to the collector by the owner or producer of the articles *to be* gauged and inspected," it is held that the collector may require prepayment of the fees before issuing the order to the gauger to gauge and inspect. This may not be practicable in the case of inspection at the distillery, as the number of packages cannot be precisely known until they are filled from the cistern, but in such cases prepayment will not generally be necessary in order to secure the fees. But in other cases, such as withdrawals from warehouse, and inspections for rectifiers, wholesale liquor dealers, &c., the number of packages may be known before the order for gauging is given. But whether this or any other course is pursued for the collection of gauging fees, the collector is required to receive and retain all amounts received as such fees, until paid to the gaugers as directed by the regulations.

The collector will report monthly to this office, on Form No. 108, the amount of fees collected by him during the month, the amounts paid to the several gaugers, accompanied by the receipt

of each gauger for the amount paid him, and the balance remaining in his hands on the last day of the month. The balance must be deposited to the credit of the Treasurer of the United States with the general collections, and be reported on Form No. 51 in an item by itself, the same as the monthly list, and on Form No. 22, using a new number, 168. The collector should charge himself with the balance thus deposited and reported on his quarterly account, Form No. 79.

From the daily returns of the gaugers, on Form No. 59, the assessor will transmit monthly to this office, on Form No. 109, a consolidated report, showing the number of packages gauged, and the fees earned by each gauger during the month. Both reports from the collector and assessor must be made promptly at the end of each month.

Collectors in districts where fees have not already been prescribed under the present law, are desired forthwith to recommend to this office what fees should be allowed for gauging in their respective districts.

Whenever it is found that the amount received by the collector for gaugers' fees exceeds the amount paid, it will be the duty of the collector to make a specific report of the facts to the Commissioner, and recommend such a change in the rate of fees prescribed as will bring the receipts as nearly as possible to balance the expenditures, as it was not the intention of the law that this should be made a source of revenue to the government. While it is impossible to regulate the scale of fees so as to produce an accurate balance each month, they will be so regulated as to produce as little excess as possible.

LABOR AND EXPENSE OF GAUGING.

Section 53 also provides that "all necessary labor and expense attending the gauging of any article shall be borne by the owner or producer of such articles." Under this clause the labor of handling and moving barrels or packages, and the cost of branding-irons, furnaces, brushes, paste, and varnish, used in marking and stamping, are to be borne by the owner or producer. Each distiller should keep the articles named on hand. Travelling expenses do not seem to be included, and gaugers cannot be authorized to collect them as part of the expense of gauging.

INSTRUMENTS FOR GAUGERS.

Hydrometers are the only instruments furnished by the government for gaugers, and these must be obtained, used, and disposed of as directed in Series 2, No. 11, and Special No. 55.

Every gauger must obtain, at his own expense, the calipers

and other gauging instruments described in Series 2, No. 11, and must use them in the manner therein prescribed.

Collectors who have not been supplied with a sufficient number of hydrometers, or manuals for inspectors containing correction tables, &c., should send their orders for the same, with proper explanations, to the Commissioner.

SACCHAROMETERS.

No saccharometer having been yet adopted, distillers may use such saccharometers for ascertaining the gravity of beer as are in good repute and general use among brewers and distillers. The name of the scale used should, however, always be noted on the yeasting book.

DISTILLERS TO KEEP BOOKS.

Every distiller (section 19) is required to make true and exact entry daily, in books to be kept for that purpose, in the form and manner set forth in Forms Nos. 12, 13, 25, and 28, which forms are hereby prescribed, of all matters therein contained; and to render an account in duplicate on Form No. 14, taken from such books, on the first, eleventh, and twenty-first days of each month, or within five days thereafter, to the assistant assessor. No materials of a kind for which a special column is provided in Form No. 13 should be entered under the head of other materials; and in Form No. 12 every kind of material purchased must be specified.

Each account must be verified under oath or affirmation by the owner, agent, or superintendent of the distillery. The oath of a clerk or other employé is not sufficient.

Upon the receipt of the return, the assistant assessor should satisfy himself, by personal examination of the books and premises, of the accuracy of the entries made, and will then transmit the same to the assessor.

ASSESSMENTS ON FORM NO. 89.

On the receipt of the distiller's first return in each month, assessors will promptly make the computation required in section 20, and report their action to this office on Form 89, whether any additional assessment is made or not for any deficiency in the return of spirits produced. The additional special tax of $4 per barrel for each barrel in excess of 100 barrels is to be made on Form No. 89, as determined by the production, and the per-diem capacity-tax is to be entered on the same form. The survey made under section 10 is the basis

for the assessment of the per-diem capacity-tax, and no return is required of the distiller therefor, as the assessment is to be made from the assessor's official records. The assessments made on Form No. 89 will be entered on the monthly lists and transmitted to the collector for collection.

Assessors and collectors will see that the various reports required to be made to them by storekeepers and other officers are promptly made, and any failure should be at once reported to the Commissioner.

INSTRUCTIONS AS TO REPORTS ON FORM NO. 89.

In order to secure correctness and uniformity in the monthly reports of assessors on Form No. 89, the following instructions are issued, and assessors will give them careful consideration and be governed strictly in accordance therewith in making up those reports.

The first question to be determined is whether or not the distiller has returned and accounted for all the spirits produced by him during the month. If the assessor finds that the distiller has not done this, then he will, from the best evidence he can obtain, estimate and determine the quantity of spirits produced over and above the quantity returned, and this, added to the quantity returned, will be the quantity which should be entered on Form No. 89 as the required product or amount to be accounted for. If the assessor finds that the whole quantity produced has been returned and accounted for, this will agree with the reported product. It cannot be less than the reported product, unless the assessor is prepared to certify that the distiller has actually returned and accounted for more than he has produced. The assessor will be understood to certify that the distiller has actually produced the quantity of spirits entered on Form No. 89 as the required product or amount to be accounted for.

Under the provisions of section 20, the assessor is required to make this investigation personally, and in so doing he is not concluded by the reports of the distiller or storekeeper, but should use every other means in his power to test the correctness of the returns.

In ascertaining and determining the quantity of materials used from the quantity of mash made, the rule laid down in the law is that 45 gallons of mash from grain shall represent *not less* than one bushel of grain, and seven gallons of mash from molasses shall represent *not less* than one gallon of molasses; that is, 45 gallons of mash must represent *not less* than a bushel of grain, but may represent more. If the distiller

actually makes but 35 or 40 gallons of mash from a bushel of grain, then 35 or 40 is the divisor to be used instead of 45.

Under the amendatory act of April 10, 1869, in distilleries in which grain or meal is mashed by hand, and without the use of steam, and which have a producing capacity of less than 100 gallons of spirits in 24 hours, 60 gallons of mash or beer brewed or fermented from grain will represent not less than one bushel of grain.

The number of distilleries within this provision is comparatively small, and in making the surveys or computations on Form No. 89, assessors will follow the instructions hereinbefore given, starting with 60 instead of 45 gallons of mash as representing not less than a bushel of grain. In all cases the inquiry should be what is the usual and average quantity of mash made from a bushel of grain.

It must be remembered that this provision applies only to distilleries where grain or meal is mashed by hand without the use of steam, the actual producing capacity of which is less than 100 gallons in 24 hours.

In ascertaining or testing the correctness of the quantity of spirits reported as produced by comparison with the quantity of material found to have been used, the assessor, if he have no more definite means, will determine what quantity of spirits should be produced from a bushel of material of the kind and quality used. Suppose, for instance, the assessor finds from the reports and otherwise that the distiller has used for the month 425,925 gallons of mash from grain. This, at 45 gallons to the bushel, would call for 9465 bushels of grain; but if the distiller actually used a thicker mash, so that 40 gallons would represent a bushel, then it would call for $10,648\frac{1}{8}$ bushels of grain. Suppose, then, the assessor finds that, under all the circumstances, the distiller has actually produced, and should be charged with, a product of 14 quarts to the bushel; he would then enter on Form No. 89, under the head of "amount of spirits required to be produced," &c., $33,127\frac{56}{100}$ gallons, at 45 gallons of mash to the bushel, or $37,268\frac{44}{100}$ gallons, at 40 gallons to the bushel.

Again, suppose that the distiller's fermenting period is fixed at 72 hours; adding the 24 hours during which each tub must remain empty, no one of the tubs can be filled oftener than once in four days. If the assessor finds that the distiller actually ferments but 48 hours, he must necessarily use more material than could have been used with 72 hours' fermentation, and, of course, must have produced more spirits.

The importance of these computations as a means of testing

the correctness of the returns of the distiller can be readily seen, and they all contain elements material to be considered in the determination of the question what is the quantity of spirits which has been actually produced by the distiller during the month.

After having determined this question, the assessor will calculate the 80 per cent. of the capacity as estimated under the provisions of the act.

To determine the 80 per cent. of the capacity, the assessor will take the number of gallons fixed by the survey as the product for 24 hours, multiply this by the number of days for which the per diem capacity-tax should be assessed; 80 per cent. of this product is 80 per cent. of the capacity as determined by the survey, and should be entered as such on Form No. 89. This is a matter of arithmetical computation, and errors are hardly excusable.

If the 80 per cent. exceeds the reported product, then an assessment must be made on the balance. If the amount actually produced is found to be correctly reported, and the amount so reported is less than 80 per cent. of the capacity as determined from the survey, the difference between the reported product and 80 per cent. must be assessed. On this point the law is imperative. But if the amount actually produced and reported equals or exceeds the 80 per cent. no assessment is to be made. Where, however, the assessor finds that the distiller has actually produced more than he has reported or accounted for, and this amount exceeds the 80 per cent., the assessment is to be made upon the difference between the amount so found and the reported product, even though the reported product exceeds the 80 per cent., because the distiller should pay upon all the spirits produced by him.

Suppose the actual product is found to be 5000 gallons; reported product 5000 gallons; 80 per cent. of capacity 6000 gallons, the distiller would be assessed upon 1000 gallons as a deficiency.

Suppose, however, the actual product is found to be 6500 gallons; reported product 5000 gallons; 80 per cent. of capacity 6000 gallons, the difference between the reported product and 80 per cent. is 1000 gallons, and between the reported product and actual product is 1500 gallons, upon which last amount the assessment should be made.

When the difference between the actual product and the reported product is greater than the difference between the 80 per cent. and the reported product, the assessment will be upon the former quantity. When the reported product equals or

exceeds the 80 per cent., but is less than the actual product, as above found, the assessment will be made upon the difference between the actual and reported product. But if in any case the actual product and the reported product are each less than the 80 per cent., the assessment must be made for the difference between the reported product and the 80 per cent.

To determine the number of barrels of 40 proof gallons each to be reported on Form No. 89 as assessed at $4 per barrel, the greatest number of proof gallons, whether the required production, the reported production, or 80 per cent. of the capacity, will be divided by 40, and the quotient, less the number exempt under the special $400 tax, will be the number to be so assessed.

Where there is a fractional number of gallons less than 40, the assessment will be made at the rate of 10 cents per gallon. This will save the necessity of carrying forward such fractional number of gallons to the next computation. The number of barrels is found from the quantity reported, together with any deficiency that may be assessed.

The per diem capacity-tax (section 13) is $2 upon the first 20 bushels or less of grain, or 60 gallons or less of molasses; and in addition thereto $2 for each even 20 bushels of grain or 60 gallons of molasses in excess of the first 20 or 60. In this assessment fractions in excess of the first 20 or 60 are to be discarded.

The number of days upon which the per diem capacity-tax is to be assessed is the whole number since the date of commencement in the month, inclusive, less Sundays and the days upon which operations have been legally suspended; due notice having been given thereof by the distiller, accompanied by the certificate of the assistant assessor that at the time the locks were placed upon the furnace-doors no mash, wort, or beer was on hand on the premises. This rule will be strictly adhered to, and all deductions made which are not supported by the official records on file in this office will be stricken out, and the assessments returned for correction.

The computations on Form 89 should be made promptly at the commencement of each month, and immediately forwarded to this office.

COMMENCEMENT OF WORK AFTER SUSPENSION.

Where a distiller resumes work after a suspension with no mash on hand, he will be deemed to have commenced the distillation of spirits at 12 meridian on the third day after the assistant assessor unlocks the furnace-doors. The full per

diem capacity-tax will be assessed from the time the furnace-doors are unlocked until work is again legally suspended. The time for estimating the 80 per cent. of the capacity will commence on the third day after, unless distilling is commenced prior to that day.

If distillation commences on the second day after the furnace-doors are unlocked, the time for which the 80 per cent. is computed will include the second day. Where such allowance is made in computing the 80 per cent., the assessor will note the fact on Form 89, stating the number of days allowed.

DISTILLERS' PACKAGES.

Under the provisions of section 23, all spirits must be drawn from the receiving cisterns into casks of not less than 20 wine gallons each. This applies to all distillers, whether of fruit or otherwise. Distillers' original packages must contain at least 20 wine gallons. Smaller packages cannot be warehoused or sold or removed by the distiller. If he sells in smaller packages, he must do it as a dealer, and such packages must be filled from the original casks or packages, and such sale cannot be made on the distillery premises.

CHANGE OF PACKAGE.

When any distilled spirits are drawn from any cask or other package, and placed in any other cask or package containing not less than 10 gallons, and intended for sale, they must be again inspected and gauged, and the cask or package into which they are so transferred marked or branded. Such mark or brand must state the kind and proof of the spirits; the particular name of such spirits, as known to the trade; the name and place of business of the rectifier or dealer, as the case may be; and, if such spirits have not been rectified, the name of the distiller; the distillery where produced; serial number of the original package, together with the name of the gauger; the time and place of inspection.

ASSISTANCE TO BE FURNISHED.

On demand of any revenue officer (section 33), every distiller or rectifier must furnish strong, safe, and convenient ladders, and supply all assistance, lights, tools, staging, or other things necessary for inspecting the premises, stocks, tools, and apparatus belonging to such person, and open all doors, and open for examination all boxes, packages, casks, barrels, and other vessels not under the control of a revenue officer in charge.

NO DISTILLERY ALLOWED TO RUN WITHOUT COMPLIANCE WITH REGULATIONS.

Under no circumstances must a distillery be allowed to run until all the requirements of the law and these regulations have been complied with; and any distillery found running without such compliance must be immediately stopped.

REVENUE OFFICERS NOT TO BE INTERESTED IN DISTILLING, ETC.

No internal revenue officer can be interested, directly or indirectly, in the manufacture of tobacco, snuff, or cigars, or in the production, rectification, or redistillation of distilled spirits, under the penalties imposed by section 97.

DISCONTINUANCE OF WAREHOUSES.

Whenever the Commissioner of Internal Revenue shall be of opinion that any warehouse is unsafe or unfit for use, or the merchandise therein liable to loss or great wastage, he may discontinue such warehouse, and require the merchandise therein to be transferred to such other warehouse as he may designate, and within a time to be prescribed by him, at the expense of the owner of the merchandise. If such transfer is not made or such expense not paid by the owner, the merchandise will be seized and sold by the collector as upon distraint.

RECTIFIED SPIRITS.

Any person (section 59) who rectifies, purifies, or refines distilled spirits or wines by any process other than by original and continuous distillation from mash, wort, or wash, through continuous closed vessels and pipes until the manufacture thereof is complete; and every wholesale or retail liquor dealer who has in his possession any still or leach-tub, or who keeps any other apparatus for the purpose of refining in any manner distilled spirits, and every person who, without rectifying, purifying, or refining distilled spirits, shall, by mixing such spirits, wine, or other liquor with any materials, manufacture any spurious, imitation, or compound liquors for sale under the name of whiskey, brandy, gin, rum, wine, spirits, cordials, wine bitters, or any other name, shall be regarded as a rectifier and as being engaged in the business of rectifying.

On and after May 1, 1869, the distinction made in the act of July 20, 1868, between rectifiers and compounders of liquors is abolished, and those who were compounders under the act of July 20 will be classed as rectifiers and be subject to all the provisions of law relating to rectifiers.

The attention of assessors is called in this connection to the provisions of section 11 of the act of July 20, 1868, and especially to the penalty imposed in the last clause of said section.

Rectifiers rectifying two hundred barrels or less per annum must pay a special tax of two hundred dollars, and fifty cents for each barrel in excess of two hundred barrels.

The payment of the special tax as a rectifier does not relieve any person from the payment of the special tax as a wholesale dealer on account of the sales of spirits, whether the same be of his own rectification or otherwise.

Rectifiers having or using any still or distilling apparatus must register the same, as provided in section 5, and must give the notice required by section 6. Every rectifier or wholesale liquor dealer must provide himself with and keep the book (Form No. 52) which is hereby prescribed. And every such book must be, at all times, kept in some public or open place on the premises of such rectifier or wholesale dealer, respectively, for inspection; and any revenue officer may examine such books, and take abstracts therefrom. Such book must be preserved, and no part thereof, or any entry therein, can be cancelled, altered, obliterated, or destroyed.

Section 46 declares it to be unlawful for any rectifier, wholesale or retail liquor dealer, to purchase or receive distilled spirits in quantities exceeding 20 gallons from any person not an authorized distiller, rectifier, or liquor dealer, except at judicial sales, or sales by an authorized auctioneer.

Under the provisions of section 59, rectifiers are required to make monthly returns on Form No. 45 of all matters therein contained, but this is not a substitute for, nor does it relieve them from, monthly returns of their sales as dealers.

LISTS OF RECTIFIERS ASSESSED FOR SPECIAL TAX TO BE FORWARDED.

Assessors will also report to this office the names and place of business of all persons who have been, or shall be, assessed a special tax as rectifiers, and will forward to this office each month a copy of the return made by each for the preceding month.

DEALERS IN LIQUORS.

Under the provisions of the amendatory act of April 10, 1869, every person who sells, or offers for sale, foreign or domestic distilled spirits, wines, or malt liquors, in less quantities than five gallons at the same time, is to be regarded as a retail dealer in liquors; and every person who sells, or offers for sale,

such spirits, wines, or liquors, in quantities of five gallons or upward, is to be regarded as a wholesale liquor dealer. This changes the distinction between wholesale and retail dealers in liquors, and assessors will take notice thereof in making the assessments for the special tax for the year commencing May 1, 1869, and correct any assessments made before receipt of these instructions accordingly.

Dealers in liquors, whether wholesale or retail, whose sales, including sales of all other merchandise, exceed $25,000, are subject to an additional tax of one dollar for each hundred dollars of sales of liquors in excess of such $25,000, and at the same rate as a wholesale dealer on every thousand dollars of sales of other merchandise. When any liquor dealer's sales shall exceed $25,000, he must keep separate accounts of his sales of liquors and his sales of other merchandise, and must return them in separate items, and will be assessed one per cent. on his sales of liquors, and $\frac{1}{10}$ of one per cent. on his sales of other merchandise in excess of such $25,000.

The exemption of distillers and brewers from special tax as dealers extends only to sales of liquors of their own production, made at the place of manufacture, and in the original casks or packages to which the tax-paid stamps are required to be affixed. The liquors must be delivered directly to the purchaser, or his agent, from the distillery or brewery premises. Dealers in liquor, who sell in quantities less than five gallons, and also in quantities of five gallons and upwards, must pay special tax both as wholesale and retail liquor dealers.

MANUFACTURERS OF STILLS.

Any person who manufactures any still or worm to be used in distilling is to be deemed a manufacturer of stills, and pay a special tax of $50; and, in addition thereto, $20 for each still or worm for distilling, made by him; *i. e.*, $20 for each still and $20 for each worm.

Any person manufacturing any still, boiler, or other vessel to be used for the purpose of distilling, must, before the same is removed from the place of manufacture, notify, in writing, the assessor of the district in which such still, boiler, or other vessel is to be set up; by whom it is to be used; its capacity, and the time when the same is to be removed from the place of manufacture.

No such still or boiler can be set up without the permit of such assessor for that purpose.

The term "for distilling," as here used, will be hereafter construed to mean "for distilling *spirits*." It is not to be under-

stood, however, that this limitation of the construction of the term furnishes sufficient grounds upon which any tax assessed under a more literal construction will be refunded.

DISTILLERS OF BRANDY FROM FRUIT.

Distillers of brandy from apples, peaches, or grapes, exclusively, are subject to the same taxes and rates of tax as other distillers. They must register their stills, give the notice, and file the bond required of other distillers, but are exempted from the additional requirements imposed upon other distillers, who are not the owners of the fee of the distillery premises, and will not be required to furnish the plan required by section 9. The survey must be made as required by section 10. They will be held subject to all the requirements of the law, as to the assessment, collection, or ascertainment of the tax due, and providing for the keeping of books, and for returns, except that instead of making returns tri-monthly, they will make return on Form No. 15 on the first day of each and every month, and the tax on the spirits distilled by them during the period embraced in their returns must be paid at the time of making their return. The tax-paid stamps must be affixed before the spirits are removed from the distillery, and upon such as remain on hand at the time the return is made.

They will not be required to provide a bonded warehouse, nor to remove the spirits produced by them from the distillery to a bonded warehouse, nor to erect receiving cistern in the distillery. They will be exempt from any penalty for non-compliance with any of the provisions of section 17; and also the provisions of section 22, in relation to suspending work; nor will they be subject to the per diem capacity-tax imposed by section 13, except for the days on which distillation is carried on. Assessors will report monthly in all cases on Form No. 89. The amendment to the law imposing a special tax upon this class of distillers is a revocation of Circular 173.

SPIRITS IN BOND JULY 20, 1868.

Under the provisions of the act of July 20, 1868, all spirits then in bond were required to be withdrawn within nine months from the passage of the act, and the casks or packages marked and stamped, and subject, in all respects, to the same requirements as if manufactured after the passage of the act.

Under the amendatory act of April 10, 1869, this time was extended until June 30, 1869; but such spirits not withdrawn prior to April 20, 1869, are made subject to an additional tax,

at the rate of one cent per gallon per month on each proof gallon deposited and bonded in warehouse. Where the time constitutes a fractional part of a month only, a proportionate amount will be collected, reckoning the tax at one-thirtieth of one per cent. per proof gallon for each day.

Upon consideration of the question, it has been determined that upon withdrawals of all spirits produced prior to July 20, 1868, the tax must be paid upon the quantity deposited in or transferred to the warehouse, in accordance with the circular letter of April 14, 1869. Under this, leakage in warehouse is not allowed, and a regauge on withdrawal is not necessary. The collector, however, may direct the gauger to regauge, if the owners of the spirits require it.

All spirits remaining in warehouse after June 30, 1869, are declared to be forfeited to the United States. The neglect to withdraw prior to July 1 works an absolute forfeiture.

All spirits remaining in any warehouse after June 30 will be immediately taken possession of by the collector, who will report the quantity, with the names of the owners, if known, at once to the Commissioner.

Spirits produced prior to July 20, 1868, which are now stored in warehouses which have been re-established as distillery warehouses, must be withdrawn and removed from such distillery warehouse in accordance with these regulations.

PERMANENT DISCONTINUANCE OF DISTILLING.

When any authorized distiller proposes to discontinue the business permanently, he must give notice to the assessor of the time at which he proposes to discontinue, who, upon receipt of such notice, will direct one of his assistants to close and secure the furnace-doors as in case of suspension of work. The distiller will also re-register his still as not for use, and make application for the discontinuance of his warehouse, withdrawing all spirits stored therein, by the payment of the tax. The assessor will report the action taken to this office, and the per diem capacity-tax will cease from the time the distillery is so closed.

CHANGE OF OWNERSHIP.

Where the title to the estate upon which an authorized distillery is located is changed by a sale, judicial or otherwise, or there is any change of ownership in the premises or distilling apparatus, or where the lot or tract of land on which the distillery stands, or any part thereof, or any of the distilling apparatus, subsequent to the approval of the bond, becomes subject to or encumbered by any mortgage, judgment, or other lien;

or any person becomes interested in the business, other than those stated on Form No. 27, it is no longer an authorized distillery. In such case there must be a new notice on Form No. 27, and all the steps taken the same as in case of a new distillery, except that the distiller may adopt or assent in writing to the correctness of the plan and survey on file, and the proper correction should be made upon the registry of the still.

REDISTILLATION ON DISTILLERY PREMISES.

Under the act of July 20, 1868, a rectifier was defined to be any person who rectifies, purifies, or refines distilled spirits by any process; and as redistillation was a purifying or refining of distilled spirits, it was forbidden to be carried on within 600 feet of any authorized distillery. By the amendatory act of April 10, 1869, original and continuous distillation from mash, wort, or wash, through continuous closed vessels and pipes, until the manufacture thereof is complete, is not deemed to be rectifying. Therefore, a distiller may after May 1, 1869, carry his product through as many processes of distillation as he pleases, provided the process is *continuous*, commencing with the distillation of the mash, wort, or wash, *the product of the distillation of the mash being carried through continuous closed vessels and pipes until the final product is deposited in the receiving cisterns.*

This does not authorize the leaching of the spirits through charcoal or any other substance; nor the purifying and refining of distilled spirits in any other mode than by redistillation; and no materials or substances whatsoever can be added during the process.

The object of the amendment was simply to allow the redistillation of spirits in copper, as formerly practised in many distilleries, provided it should be done under the restrictions named. The apparatus must be so constructed that there can be no access had to the spirits on its passage through the pipes and vessels connecting the beer still with the receiving cisterns. Under these restrictions an alcohol column may be substituted for one of the doublers.

STAMPS FOR DISTILLED SPIRITS.

From and after November 1, 1868, stamps for distilled spirits will be required to be used in all cases as provided by law.

These stamps are engraved and bound in book form, the books of tax-paid stamps containing one hundred and fifty and three hundred stamps each, and the others four hundred each.

The tax-paid stamps are for 20, 30, 40, 50, 60, 70, 110, 120, and 130 gallons, with nine coupons attached, each coupon representing one gallon.

These stamps will be issued to collectors upon their requisitions in such numbers as may be required, and will be charged to them at the full value of the stamps, or at the full value of the tax on the number of gallons represented on the stamps and coupons.

It is the duty of the collector to return to this office any book of marginal stubs as soon as the stamps contained therein have been used; and when he has accounted for the tax on the number of gallons represented on the stamps and coupons that were contained in any book of tax-paid stamps, there will be allowed a commission of half of one per centum on the amount of the tax on spirits distilled after the passage of the act of July 20, 1868, to be equally divided between the assessor and collector.

The books containing other than the tax-paid stamps may be intrusted by the collector to a gauger, whenever he may deem it necessary so to do, and he may require such gauger to give security to return or account for all such stamps. Such gauger must make a daily report to the assessor and collector on Form No. 118 of all such stamps used by him, and for whom used, and from these reports the assessor will, on the first of each month, assess the person for whom they were used at the rate of 25 cents for each stamp used during the preceding month, and return the same to the collector for collection. These assessments should be transmitted to the collector with the monthly list, but should not be included in the aggregate of the list nor be receipted for on Form No. 23½. When all the stamps contained in these books shall have been issued, the collector will return the books with the marginal stubs therein to this office.

The stubs must in no case be removed from any of the books, and all unused coupons must remain attached to the marginal stubs. No coupon will be of any value when detached from the stamp or stub. Collectors will be credited with the amount of the tax on the number of gallons represented by all coupons attached to the stubs returned to this office.

The tax-paid stamps, as well as the other stamps, must be signed by the collector in his own handwriting, and the blanks in the stubs must be filled so as to preserve a perfect record of the use of the stamps when attached.

The amount actually received for all kinds of stamps for spirits should be reported monthly on Form No. 90, and also

on Form No. 51, in the same manner that receipts from the sale of beer stamps are now reported.

DISTILLERY WAREHOUSE STAMPS.

The law imperatively requires that all spirits produced in any distillery shall be drawn off from the receiving cisterns at least once in three days, and to be gauged and marked and immediately removed to the distillery warehouse. The gauger will mark the casks as hereinbefore required, and affix the appropriate stamp to each cask as required. If the book of stamps is not in possession of the gauger, the collector or deputy collector will issue the stamps upon the report of the gauger in detail of his inspection, keeping an account of the number of stamps so furnished to each distiller, and will report to the assessor at the end of each month the number of stamps other than the tax-paid stamps so issued by him and to whom issued.

TAX-PAID STAMPS.

Whenever any person desires to withdraw spirits from a warehouse, he will notify the collector or deputy collector, who will upon receipt of the tax cut from the book stamps with the requisite coupons annexed, properly filled up and signed, which will be affixed by the gauger, in presence of the storekeeper, to a smooth surface on the head of the respective casks, as hereinafter directed.

At the time of affixing the tax-paid stamps, the gauger will, in presence of the storekeeper, brand the cask as hereinbefore provided in accordance with the provisions of section 25. A stencil-plate cannot be used for this purpose. This brand must not in any case be obliterated or cancelled, except as provided in section 25, by cutting or burning a cancelling line across such brand or mark; and no stamp, mark, or brand must be effaced or in any manner obliterated until such cask is emptied or its contents drawn off.

STAMP FOR RECTIFIED SPIRITS AND WHOLESALE DEALERS' STAMP.

Whenever any cask or package of rectified spirits is filled for shipment, sale, or delivery, on the premises of any authorized rectifier, or when any cask or package of distilled spirits is filled for the same purpose on the premises of any wholesale dealer, it is the duty of the gauger to gauge and inspect the same, and place thereon the stamp for rectified spirits, or wholesale dealers' stamp, as the case may be.

The provisions of section 25 cover all packages filled for shipment, sale, or delivery upon the premises of any authorized rectifier or of any wholesale dealer. As the law explicitly requires all such packages to be gauged and stamped, the rectifier or dealer must put up his spirits in casks or packages of a kind which will admit of the attachment of the stamps as required by law.

Where the contents of any cask or package are transferred on the premises of a rectifier or dealer to another cask or package of not less than ten gallons capacity, there must be in addition to the stamp for rectified spirits or wholesale dealers' stamp the marks and brands required by section 47. The requirements of section 47 are not a substitute for, but in addition to the requirements of section 25.

AFFIXING, CANCELLATION, AND COVERING OF STAMPS.

By virtue of section 25, act of July 20, 1868, it is hereby prescribed that the affixing, cancellation, and covering of stamps placed on casks or other packages containing distilled spirits, shall be done in the following manner, viz:—

Affixing.—The stamps are to be securely affixed to a smooth surface of the cask or package. That surface must not have been previously painted or covered with any substance. Transparent varnish, or any other adhesive material which will cause the stamp to stick securely and permanently, may be used for that purpose. The affixing will be done by the gauger in the presence of the storekeeper.

Cancellation.—The stamp having been affixed, it must immediately be cancelled. For this purpose the gauger will use a stencil-plate of brass or copper, in which will be cut not less than five fine parallel waved lines, long enough to extend not less than three-quarters of an inch beyond each side of the stamp, on the wood of the cask; and the name of the gauger must be cut on one end of the plate, and his title, viz., "U. S. Gauger," on the other end, perpendicular to the lines. This plate must be imprinted, with blacking or durable coloring material, over and across the stamp as indicated, and in such a manner as not to deface the reading-matter on the stamp; that is, so as not to daub and make it illegible.

Covering.—The stamp having been affixed and cancelled, it must immediately be covered with a coating of transparent varnish or other substance. Any transparent varnish or other similar substance may be used for this purpose.

EMPTY CASKS OR PACKAGES.

By the provisions of section 43, every person who empties or draws off, or causes to be emptied or drawn off, any distilled spirits from any cask or package bearing any mark, brand, or stamp required by law, must, *at the time of emptying such cask or package*, efface and obliterate such mark, brand, or stamp. Any empty cask or package from which the mark, brand, or stamp has not been effaced or obliterated is declared to be forfeited, and any internal revenue officer should seize the same wherever found.

Any person or transportation company who shall receive or transport, or have in possession with intent to transport or to cause or procure to be transported, any such empty cask or package, *or any part thereof*, having thereon any brand, mark, or stamp required to be placed on casks or packages of distilled spirits, is liable to a penalty of $300 for each such cask or package, or any part of such cask or package; and any boat, railroad car, cart, or other vehicle, and all horses or other animals used in carrying or transporting the same, are to be forfeited.

Any person who shall fail or neglect to efface and obliterate such mark, brand, or stamp *at the time of emptying such cask or package*, or who shall receive any such cask or package, or any part thereof, with intent to transport the same, or who shall transport the same, or knowingly aid or assist therein, or who shall remove any stamp from any cask or package without defacing or destroying the same at the time of such removal, or aid or assist therein, or who shall have in his possession any such stamp so removed, or who shall have in his possession any cancelled stamp or any stamp which has been or purports to have been used, is deemed guilty of a felony, and to be punished by fine and imprisonment.

The attention of all officers of internal revenue is specially called to the provisions of this section. From all the provisions it is clear that the intent of the law is to require that the marks, stamps, and brand on any cask of spirits shall be effaced and destroyed at the time the cask is emptied, and the responsibility of doing this is placed upon the person emptying it. The terms "efface and obliterate" must be understood to mean a complete destruction, so as to leave no part or portion of the marks, stamps, or brand legible or intelligible. Persons who have possession of, deal in, or are engaged in the transportation of empty spirit casks or packages should understand their liability. If they violate the law, the penalties, though severe, must be

enforced, and ignorance of its provisions, negligence, or carelessness on the part of themselves or their subordinates is not a sufficient excuse. The offence, if committed, is declared to be a felony, and there is no power to compromise.

MARKING AND BRANDING CASKS.

The attention of all officers of internal revenue is called to the regulations in relation to marking and branding of casks or packages of distilled spirits, a strict compliance with which is enjoined upon all officers, and especially gaugers.

Complaints have been made that there is a great lack of uniformity among the gaugers in carrying out the regulations, and it is charged that, in some districts, the regulations have been persistently and deliberately disregarded. There is no difficulty in understanding the regulations, and all officers are notified that they must be strictly complied with.

It has also been found that the stamps for distilled spirits are in many instances negligently and insecurely attached. This is almost entirely the result of carelessness on the part of the gauger and undue haste in affixing the stamp.

Care must be taken to attach the stamps securely and smoothly to a clean surface, and the gauger must take time enough to do so. After it is so affixed it should be cancelled as prescribed, and then covered with the transparent varnish. This is a matter for which the gauger will be held responsible, and a desire to do the greatest amount of work in the shortest space of time will not be accepted as an excuse for a failure to do the work well.

Collectors and other seizing officers are instructed to detain or seize any and all casks or packages of spirits which are not marked and branded as required by these instructions, and forthwith report the facts to this office. The owner of the spirits will find it for his interest to insist that the gauger does his work correctly.

Any neglect to mark and brand spirits as required by the regulations, or any case of negligence or carelessness in attaching the stamps, should be at once reported to this office, that the proper steps may be taken for the dismissal of the officer so doing; and collectors will also be justified in declining to assign any gauger to duty who shall be found guilty of such negligence, carelessness, or disregard of the regulations.

C. DELANO, *Commissioner.*

REGULATIONS CONCERNING THE DISTILLATION OF BRANDY FROM APPLES, PEACHES, OR GRAPES, EXCLUSIVELY.

TREASURY DEPARTMENT, OFFICE OF INTERNAL REVENUE,
Washington, July 1, 1870.

EXEMPTIONS.

UNDER the provisions of section 2 of the act of July 20, 1868, the Commissioner of Internal Revenue is authorized, with the approval of the Secretary of the Treasury, to exempt distillers of brandy from apples, peaches, or grapes, exclusively, from certain requirements of said act relating to the manufacture of spirits; and, therefore, by virtue of said authority, and with the approval of the Secretary of the Treasury, I hereby exempt all distillers of brandy from apples, peaches, or grapes, exclusively, from the following provisions of said act, and the acts amendatory thereof, to wit:—

From all of the provisions of sections 3, 8, 9, 15, 18, 21, 22, 24, and 45 of the act of July 20, 1868, and so much of the act of April 10, 1869, as is amendatory to section 8 of said act; and from portions of the following-named sections of said act of July 20, 1868, to wit:—

So much of section 6 as requires the distiller to state in his notice the number of mash tubs and fermenting tubs, and the cubic contents of each tub, the number of receiving cisterns and the cubic contents of each cistern, and the number of hours in which the distiller will ferment each tub of mash or beer. So much of section 7 as provides that in no case shall the distiller's bond be for a less sum than five thousand dollars. So much of section 12 as provides that no person shall use any still, boiler, or other vessel for the purpose of distilling, in any shed, yard, or inclosure connected with any dwelling-house. From all of the provisions of section 17, except so much thereof as provides that "no assessor shall approve the bond of any distiller until all the requirements of law and all regulations made by the Commissioner of Internal Revenue in relation to distilleries, in pursuance thereof, shall have been complied with," and the penalty relating thereto. From all of section 19,

except so much thereof as provides for the keeping of a book or books, in the manner to be prescribed by the Commissioner of Internal Revenue, the preservation of such book or books for the inspection of revenue officers, and the penalties pertaining thereto, and the making of returns: *Provided, however,* That the manner of making such returns shall be as prescribed in these regulations.

So much of section 20 as provides that forty-five gallons of mash or beer brewed or fermented from grain shall represent not less than one bushel of grain, and seven gallons of mash or beer, brewed or fermented from molasses, shall represent not less than one gallon of molasses; and so much of section 1 of the act approved April 10, 1869, as is amendatory thereof.

From all of the provisions of section 23, except so much thereof as requires that all distilled spirits shall be drawn into casks, and shall be gauged, proved, and marked by a United States gauger, by cutting on the cask containing such spirits, in a manner to be prescribed by the Commissioner of Internal Revenue, the quantity in wine gallons and in proof gallons of the contents of such cask, and the serial number of the package, in progressive order.

From so much of section 25 as provides for the receiving of an order from the collector for the removal of spirits from distillery warehouse; and from so much thereof as requires that the affixing of the tax-paid stamp, and the cutting or burning of the serial number of the stamp, shall be done by a gauger.

From so much of section 1, act April 10, 1869, as requires that spirits purified or refined in the original course of manufacture must be by continuous distillation through continuous closed vessels and pipes until the manufacture thereof is complete.

Distillation from the aforesaid fruits, or from the undistilled products of either or all of these fruits, exclusively, is regarded as a distillation from the fruit.

REGULATIONS.

1. (Section 5.) Every still in the possession of any person must be registered on Form 26, either as being for use or not for use; and all stills that have not been so registered must be forthwith registered by the person in possession thereof, with the assessor of the district, or the assistant assessor of the division in which such still is situated. An omission to so register incurs a penalty of five hundred dollars.

2. (Section 6.) Each person having a still so registered, and

intending to use the same for the distillation of brandy from apples, peaches, or grapes, must, before commencing distillation, give notice on Form 27½ to the assessor of his district, direct or through the assistant assessor of his division, of his intention to distill, stating in such notice his name and place of residence, and, if a company or firm, the name and place of residence of each member thereof; the place where said business is to be carried on; the number and kind of stills; the total capacity of each in gallons; the manner in which the same is to be boiled, whether by steam or furnace heat; the kind of fruit proposed to be used; the building or place on the premises where the distillery is situated in which he will deposit and keep the brandy to be distilled by him until the tax is paid thereon and the tax-paid stamps attached thereto; and that such still or stills are not within six hundred feet of any premises authorized to be used for rectifying or refining distilled spirits by any process.

3. (Section 10.) On the receipt of notice, Form 27½, the assessor, with the aid of his designated assistant, will proceed to make a careful survey of such still or stills, in accordance with the provisions of section 10 of said act of July 20, 1868, unless there be on file in his office a correct survey thereof theretofore made, and it appearing to his satisfaction that no change has taken place in the capacity of such still or stills since the making of such survey.

4. (Section 7.) After the completion of such survey, and before the commencement of distillation, each distiller shall make and execute a bond on Form No. 30½, with at least two sureties to be approved by the assessor of the district. The penal sum of said bond shall not be less than double the amount of the tax on the spirits that can be distilled in his distillery during a period of thirty days, as ascertained by the survey, and in no case shall such bond be for a less sum than five hundred dollars. Bonds so given expire on the last day of April of each year, and parties must renew their bonds before continuing or again engaging in distillation after that date. A new bond may be required, in case of the death, insolvency, or removal of either of the sureties, and in any other contingency, at the discretion of the assessor or Commissioner of Internal Revenue. On the presentation of such bonds to the assessor, he shall examine the same and satisfy himself that they are correct in form and duly executed according to law; that the sureties thereon are residents of the district, or of some county adjoining the district within the same State; and that such sureties are ample security for the

amount of such bond, and for that purpose may require from such sureties affidavits, abstract of title, or other evidences as to their solvency. The assessor shall indorse his approval on each bond, certifying that the bond is properly filled up and executed, and that the sureties thereon are, in his belief, sufficient.

Under the provision of section 59, as amended in the act of April 10, 1869, distillers of brandy from apples, peaches, or grapes, exclusively, producing less than one hundred and fifty barrels annually, are required to pay a special tax of fifty dollars per annum, and every such distiller producing more than one hundred barrels of forty proof gallons each within the year, shall pay an additional tax of four dollars for each and every such additional barrel over one hundred barrels.

The special tax of fifty dollars is an annual tax, commencing with the first day of May, of each year, and when paid within the year is to be estimated on the unexpired portion of the year, at the rate of fifty dollars per annum. For instance, a party commencing business in May, pays fifty dollars, but a party commencing business in September, pays but $\frac{8}{12}$ of $50, or $33 33. The party paying the $50, is exempt from further special tax on the first one hundred barrels, forty proof gallons each; while the party paying the $33 33, is exempt on the first sixty-six and two-third barrels; and each party must pay the additional tax of four dollars per barrel upon every barrel in excess thereof. The special tax is to be charged for all of the month within which the bond is approved, no fractions of a month being recognized in estimating this tax, and the exemption from barrel tax is to be applied to the first barrels produced within the year.

5. (Section 19.) Every distiller from fruit must provide himself with a book in accordance with Form No. 25½, which is hereby prescribed by the Commissioner of Internal Revenue, in which he shall, from day to day, make or cause to be made a true and exact entry of the hours between which the still is operated each day; the kind, quantity, and condition of the fruits used; the number of times each still has been boiled off during each day, and the quantity of singlings and of brandy produced thereby; which book must be always kept open to the inspection of any revenue officer, and, when filled up, shall be preserved by the distiller for the period of not less than two years thereafter, and whenever required shall be produced for the inspection of any revenue officer. Severe penalties are provided in the law for making false entry in such book, or for fraudulently altering any entry made therein, or for omitting to make or have made the entries required.

Distillers are at liberty to procure the book in any way they see fit. All of the foregoing requirements must be complied with by the distiller before the assessor can approve his bond, and the distiller must not commence work at his distillery before the bond is approved and the special tax paid.

On completing the process of distillation, the distiller must draw the brandy distilled by him into casks, each of not less capacity than ten gallons, wine measure, and must retain the same at the designated place of deposit at the distillery until the tax is paid thereon and the tax stamps attached thereto, as hereinafter directed.

Severe penalties are provided in the law for altering, changing, consuming, or removing the spirits before the tax is paid thereon and the tax stamps attached thereto.

6. (Section 25.) On or before the 25th day of each month, the distiller shall notify the collector of his district, on Form A, stating the probable number of packages of brandy that will be distilled by him within the month, and probable number of wine gallons, with his request to have the same gauged and marked; and on the receipt of such notice, and after the last day of the month, the collector of the district shall cause the brandy produced during the month to be gauged, proved, and marked, as hereinafter directed, by a United States gauger, who, upon order of the collector, shall proceed at once to gauge, prove, and mark each package of such spirits as he may find at the distillery or designated place of deposit; and shall cut upon the bung stave of each package the wine gallons, the proof, and the proof gallons; and shall cut or burn on the head of each cask the name of such distiller, the district, the serial number of the cask and kind of spirits; and shall mark thereon the date of such gauge and the name of the gauger by whom made, placing such date and name on the head of the package in such way as to admit of the attaching of the tax-paid stamp between the same. The gauger, on completing each inspection, shall immediately make report thereof, in triplicate, on Form 59½, showing for whom gauged and where, the number of packages, the serial number of each, the proof, the wine gallons and the proof gallons of each, the kind of spirits and the amount of tax thereon, and sign the same, delivering one copy thereof to the distiller, and transmitting one copy thereof to the assessor and one to the collector of the district. The fees for such gauging to be paid by the distiller, at such rates as are or may be prescribed by the Commissioner of Internal Revenue.

Immediately on the receipt of such return from the gauger, and on or before the tenth day of each month, the distiller

shall make a return, in triplicate, on Form 15, showing the number of days within the preceding month upon which his stills were operated; between what hours of each day operated; the kind, quantity, and condition of fruit used, and the number of times each still was boiled off each day; the quantity of singlings produced; the aggregate number of wine and of proof gallons of brandy distilled during the month, and quantity of singlings on hand at the end of the month; which return shall be signed by the distiller and sworn to by him before the assessor, assistant assessor, or some other officer having general power to administer oaths, and shall be transmitted to the assessor, who, on receipt thereof, shall forthwith transmit one copy to the Commissioner of Internal Revenue and one copy to the collector of the district.

Having exempted distillers of brandy from apples, peaches, or grapes, exclusively, from the provisions of the law requiring that redistillation be carried on through continuous closed pipes and vessels, it is necessary that the distiller shall complete the process of distillation of his production within the month, so as to have no singlings on hand at the end of the month beyond the production of the last two days, and even this amount should be doubled, where it is possible to do so, within the month, and embraced in the return as brandy.

On payment of the tax upon the brandy, as shown in the gauger's report, the collector shall prepare tax-paid stamps of the proper denomination, with all the blanks filled up according to the facts as appearing in such gauger's return, including the serial number of the package to which each stamp is to be attached, which stamps shall be signed by the collector, as well as by the gauger making the return, and delivered to the distiller.

Upon the receipt from the collector of the tax-paid stamps, the distiller shall affix the same to the packages in a secure and permanent manner, by pasting the same upon the head of the packages, at the place previously designated by the gauger, and by driving tacks, one in each corner, one in the centre and at each side of the stamp, making not less than seven in number; and shall cancel the same, by writing across the face of the stamp his name and the date upon which the stamp is affixed to the package, and varnish the stamp with a transparent varnish, so as to protect it from removal or damage by exposure; and shall cut or burn, in legible figures, upon the head of each cask, the serial number of the stamp attached thereto, and the date of the payment of the tax. In attaching the stamps, the distiller must be careful to attach each stamp to the package the serial number of which is given in the

stamp; and on having so attached the stamps to each package, he shall make entry of the serial number of each package, and of the stamp attached thereto, in the proper column in his book, Form 25½, together with the aggregate amount of tax paid; and on selling or disposing of the packages so stamped, shall enter on his book to whom sold or delivered.

Any distiller of brandy from apples, peaches, or grapes, desiring to avail himself of the privileges of a distillery warehouse, and of the bonding of the spirits of his own manufacture therein, may do so on complying with all the requirements of law in regard thereto, the same as if such provisions had not been included in the exemptions set forth in these regulations.

The brandy, when put up, marked, and stamped as hereinbefore required, may be disposed of by the distiller under the authority of the ninth paragraph of section 1, act April 10, 1869, by sale or otherwise, at the place of manufacture, in the original casks or packages to which the tax stamps are affixed. Distillers, desiring to retain the brandy for their own consumption, must put it up, mark it, and stamp it, the same as if intended for sale. Under these regulations, it is permissible that a distiller, legally authorized, may receive either of the fruits named or the undistilled products thereof from another person for the purpose of distillation, returning to that other person all or a part of the brandy produced therefrom; but in such case the Government recognizes no person in the transaction but the distiller, and the brandy when distilled must be put up, marked, and stamped, the same as if distilled by the distiller from his own fruits, and for his own consumption or sale. Distillers cannot dispose of the brandy distilled by them in any other than the tax-stamped packages, nor at any other place than the place of manufacture. Every distiller is required, from the date of the approval of his bond until he permanently discontinues business at his distillery, to render all the monthly notices and returns required, whether any distillation has been had at his distillery within the month or not; and where no distillation has been had, the returns shall show that fact. Distillers, desiring to permanently discontinue business, must do so by re-registering their stills as not for use, on Form 26, which form shall be executed in duplicate, and delivered to the assistant assessor of the division, who, on receipt thereof, will see that the still (or stills) is so dismantled as to prevent further distillation, and when so dismantled shall transmit said Form 26 to the assessor of the district, who, on receipt thereof, shall register such still as not for use, and transmit one copy of said Form 26 to the Commissioner of Internal Revenue.

7. (Section 20.) On the receipt of the distiller's return, Form

15, in each month, the assessor shall inquire and determine whether said distiller has accounted in his return for the preceding month for all the brandy produced by him; and if the assessor is satisfied that the distiller has returned all the spirits produced by him, he will enter the quantity so reported on Form 89 as the amount to be accounted for during that month. If the quantity so reported by the distiller is less than 80 per cent. of the surveyed capacity of the distillery for the time run and material used, the assessor will assess the distiller 50 cents per proof gallon for every gallon of such deficiency, together with the special tax of $4 per barrel for every barrel of 40 proof gallons each; provided, that no tax of $4 per barrel shall be assessed until the number of barrels exempted under the special tax has been produced. If the assessor finds, upon an examination, that the distiller has not reported all spirits actually produced by him during the month, he will ascertain the quantity actually produced.

In determining the amount actually produced, the assessor shall ascertain the kind and quantity of materials used, and the time operated, and determine such amount therefrom, on the basis of the spirit-producing capacity of the materials used as fixed in the survey.

The time will be arrived at by aggregating the hours run and dividing by 24, counting any fraction as a whole day. In the absence of a satisfactory return of the materials used and time operated, he may base his estimate of actual production upon the surveyed capacity of the distillery for the period which it is ascertained it was operated, fixing the production at the full capacity thereof.

Whenever the actual production of brandy within the year shall be equal to the number of barrels exempted under the special tax, there shall be an additional tax of four dollars per barrel, forty proof gallons, for every barrel in excess of the number so exempted.

No assessment for per diem tax will hereafter be made against distillers of brandy from apples, peaches, or grapes, exclusively.

8. *Instructions for making Surveys.*—(Section 10.) Under the provisions of section 10 of the act of July 20, 1868, the true producing capacity of each distillery must be ascertained and determined by the assessor of the district and the skilful person designated by the Commissioner of Internal Revenue to assist him therein. These designated assistants are appointed on the recommendation of the assessor of the district, and assessors should see that a sufficient number of suitable persons are recommended for appointment to meet all the requirements of

the service. The reports of the surveys thus made are to be made out in triplicate on Form 99, signed by the assessor and his designated assistant, and one copy thereof delivered to the distiller, another retained by the assessor, and the third transmitted to the Commissioner of Internal Revenue, with the certificate of the assessor thereon showing the date on which the copy was delivered to the distiller.

Fruit distilleries having no ascertainable mashing or fermenting capacity, the true producing capacity thereof is determined solely on the capacity for distillation. This is arrived at by determining, first, the capacity in gallons of each still, making proper deduction for boiling space; second, the number of boilings of each still that can be effected in twenty-four hours, of each condition of the material to be used; and, third, the spirit-producing capacity of the material in each condition.

The capacity in gallons of each still may be ascertained either by arithmetical calculation, or by filling the same and measuring the contents. When done by filling and measuring the contents, the columns in Form 99 for diameters may be left blank, and a note entered on the face of the report showing that the capacity was ascertained by measurement of contents. Twenty per cent. must be deducted from the total capacity of each still, as an allowance of space for boiling. For instance, a still holding one hundred gallons will boil eighty gallons.

The number of boilings that can be effected of each material in twenty-four hours is to be determined in view of the appliances in use for that purpose. When steam is used, a greater number of boilings can be ordinarily effected than where furnace heat is used; and the number of boilings that can be effected with furnace heat depends upon the shape of the still and the amount of the surface exposed to the action of the heat, and the manner in which the still is set. It is believed that ordinarily seven boilings of fruit, in any of the conditions in which it is used, may be had in twenty-four hours.

The total number of boilings that can be had having been ascertained, proper deduction should be made for doubling; as, for instance, a still that can be boiled off seven times in twenty-four hours may require two boilings to double the singlings produced, thus leaving a capacity of five boilings in twenty-four hours.

Apples, peaches, and grapes, from which brandy is distilled, are used in such a variety of conditions, in different sections of the country, that it is difficult to give a classification of these materials which will embrace every condition in which they may be used. The following classification will, however, be found sufficiently comprehensive to embrace any of the ordinary conditions in

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which the fruit is distilled, viz., pomace, cider, must, sour wine, wash, cheese, and lees. The blanks will be found to contain a column for "other material," in which to embrace material not clearly coming under either of the above classifications.

By pomace, is meant the crushed fruit without the juice expressed therefrom; cider, the expressed juice of the apple; must, the unfermented juice of the grape; sour wine, the fermented juice of the grape; cheese, the residue of the fruit after the juice has been expressed therefrom; wash, is the liquid expressed from the cheese of apples or grapes, after adding water thereto; lees, or "*piquette*," the dregs or settlings of wine. The spirit-yielding capacity of these several conditions of the fruits is so variable, that it is difficult for this office to lay down any fixed rules on the subject, but it must necessarily leave the determination of the amount of spirits to be produced from a given quantity of each of these materials to the judgment of the assessor and his designated assistants, they acting upon the most reliable information that can be obtained from past experiences in the particular locality in which they are making the surveys.

From the information contained in the records of this office, and derived from other reliable sources, it is believed that proof brandy may be distilled from these materials, as follows: One gallon from every 17 gallons of apple or peach pomace; one gallon from every 8 gallons of grape pomace; one gallon from every 12 gallons of cider; one gallon from every 5 gallons of must; one gallon from every 7 gallons sour wine.

The spirit strength of the other materials must be determined solely in the light of experience in each particular locality. This office is not prepared to give any rules relative thereto.

Having thus ascertained the number of gallons of each material that can be distilled in twenty-four hours, and the spirit strength thereof, the capacity of the still or stills for twenty-four hours is readily arrived at.

In the absence of the printed blanks furnished by this office, the notices, returns, bonds, &c., required by these regulations, may be made up from the following forms. All of these forms will be furnished to the assessor or collector of the district, for the use of distillers, excepting the book Form No. 25½, and the notice from the distillers of spirits to be gauged, Form A.

These regulations shall go into full force and effect on and after the 1st day of July, 1870; and thereupon all former regulations inconsistent herewith will be superseded.

C. DELANO, *Commissioner.*

Approved:

GEO. S. BOUTWELLL, *Secretary of the Treasury.*

BLANK FORMS.

(26.)

UNITED STATES INTERNAL REVENUE.

REGISTRY OF STILLS.

[To be returned in duplicate to the Assistant Assessor by every person having in his possession or custody, or under his control, any still or distilling apparatus set up. Persons failing to register, become liable to a penalty of five hundred dollars, and fine of not less than one hundred dollars nor more than one thousand dollars, and imprisonment for not less than one month nor more than two years, in addition to forfeiture of the still and all personal property found in the building, &c., where the same shall be set up. (Act of July 20, 1868, section 5.) A copy of each notice on this form is to be immediately forwarded to the Commissioner of Internal Revenue.]

List of stills and distilling apparatus set up at No. —— ——— street, in the ——— of ———, county of ———, and State of ———, in the ——— division of the ——— collection district of said State, owned by —— ———.

Names of owners.	Residence. (Number and street, if in a city.)	Kind of still.	Serial No. of still.	Cubic contents. Gallons.	For what purpose used.	Whether or not intended to be used.

(Signed) —— ——.

Received for registry, this —— day of ———, A. D. 187–.

—— ———,
Assistant Assessor ——— Division,
——— Collection District, ———.

(27½.)

UNITED STATES INTERNAL REVENUE.

NOTICE BY DISTILLERS OF APPLES, PEACHES, OR GRAPES, EXCLUSIVELY.

[To be returned to the Assessor of the District by every person engaged in, or intending to be engaged in, the business of a fruit distiller. Persons failing to give notice, become liable to a penalty of one thousand dollars and a fine of not less than one hundred dollars nor more than two thousand dollars. Act of July 20, 1868, section 6.]

——, ——, 187–.

Notice is gereby given, That ——, of the —— of ——, county of ——, and State of ——, intend, under the name or style of ——, to carry on or engage in the business of distilling brandy from apples, peaches, or grapes, exclusively, at the distillery operated by ——, situate No. —— street, in the —— of ——, county of ——, —— district of ——, known as Registered Distillery No. ——, and that the following utensils will be used in said business, viz:—

Number and kind of stills and capacity of each in gallons

Manner of boiling (whether by steam or furnace heat)

Kind of fruit proposed to be used

Estimated quantity of brandy capable of being produced every twenty-four hours

Distance of distillery from nearest place or premises authorized to be used for rectifying or refining distilled spirits

The brandy manufactured at said distillery will be deposited and kept at the following-described place, situated on the same premises with said distillery, until the tax shall be paid thereon and the tax-paid stamps attached thereto, to wit:—

Name of every person interested, or to be interested, in the business, and nature of interest, with residence (if in a city, designated by street and number):

(Signed) —— ——.

To —— ——,
Assessor —— District ——.
Received this —— day of ——, A. D. 187–.

—— ——, Assessor.

☞ In case of any change in the location, form, capacity, ownership, agency, superintendency, or in the persons interested in the business of such distillery, notice thereof, in writing, stating the particulars of such change, and asking that such notice may be annexed to and made part of the original notice on this Form, must be given to the Assessor or Assistant Assessor of the Division within twenty-four hours of such change.

Copies of all notices given on this Form must be immediately forwarded to the Commissioner of Internal Revenue, and also copies of all subsequent notices of any changes as above noticed.

Under the provisions of Section 11, the processes of distillation and rectification cannot both be carried on within the distance of six hundred feet; and any Assessor who assesses, or Collector who collects, any special tax in such case, is liable to a penalty of five thousand dollars.

(99.)

UNITED STATES INTERNAL REVENUE.

SURVEY OF STILLS USED FOR DISTILLING BRANDY FROM APPLES, PEACHES, OR GRAPES, EXCLUSIVELY.

Survey of Distillery at No. ——, at ——, in the —— of ——, County of ——, and State of ——, in the —— division of the —— collection district of said State, owned by —— ——.

Number and kind of stills.	Greatest diameter.	Least diameter.	Mean diameter.	Height.	Cubic contents.	Working capacity.	No. of boilings in 24 hours by steam.											No. of boilings in 24 hours, furnace heat.									
							Apple pomace.	Peach pomace.	Grape pomace.	Cider.	Must.	Sour wine.	Wash.	Cheese.	Lees or piquette.	Other material.		Apple pomace.	Peach pomace.	Grape pomace.	Cider.	Must.	Sour wine.	Wash.	Cheese.	Lees or piquette.	Other material.
	Inches.	Inches.	Inches.	Inches.	Gallons.	Gallons.																					

Gallons of material required to produce one gallon of proof brandy.											Brandy-producing capacity in 24 hours. Proof gallons.									
Apple pomace.	Peach pomace.	Grape pomace.	Cider.	Must.	Sour wine.	Wash.	Cheese.	Lees or piquette.	Other material.		Apple pomace.	Peach pomace.	Grape pomace.	Cider.	Must.	Sour wine.	Wash.	Cheese.	Lees or piquette.	Other material.

Survey made on the —— day of ——, A. D. 187–.

—— ——, Assessor —— District of ——.
—— ——, Designated Assistant.

I certify that a copy of this survey was delivered to ——, Distiller, on the —— day of ——, 187–.

—— ——, Assessor.

NOTE.—In case any still is so irregular in form that it cannot be accurately measured in any other manner, it may be filled with water, and the contents drawn off and measured.

(30½.)

UNITED STATES INTERNAL REVENUE.

FRUIT DISTILLER'S BOND.

[Bonds given on this Form expire on the last day of April in each year, and must be renewed before continuing or again engaging in distillation after that date.]

Know all men by these presents, That we, ———, as principal, and ———, as sureties, are held and firmly bound unto the United States of America in the full and just sum of ——— thousand dollars, money of the United States; to which payment, well and truly to be made, we jointly and severally bind ourselves, our heirs, executors, and administrators, firmly by these presents.

Sealed with our seals, and dated this —— day of ———, A. D. 187–.

The condition of the foregoing obligation is such, that whereas the said ——— now ———, or intend, on and after the —— day of ———, 187–, to be engaged in the business of distilling brandy from apples, peaches, or grapes, exclusively, within the —— Collection District of the State of ———, to wit, at Registered Distillery No. ——, situate in the ——— of ———, county of ———, and State aforesaid:

Now, therefore, if the said ——— shall in all respects faithfully comply with all the provisions of law and regulations in relation to the duties and business of distillers of brandy from apples, peaches, or grapes, exclusively, and shall pay all penalties incurred or fines imposed on him for a violation of any of the said provisions, then this obligation shall be void; otherwise, it shall remain in full force.

——— ———.
——— ———.
——— ———.

Signed, sealed, and delivered in presence of—

——— ———.
——— ———.

☞ The following instructions must be particularly observed and complied with, viz:—

1st. The Christian names must be written in the body of the bond in full, and so signed to the bond.

2d. The residence of each signer must be stated in the bond.

3d. A seal of wax or wafer must be attached to each signature.

4th. Each signature must be made in the presence of two witnesses, who must sign their names as such.

5th. There must be at least two sureties, and the bond must be dated.

6th. A twenty-five cent stamp must be affixed and cancelled.

7th. The penal sum named in the bond must not be less than double the amount of the tax on the spirits that can be distilled, during a period of 30 days, by the still or stills of which the person giving the bond has notified the Assessor, nor shall it be in any case less than five (hundred) dollars, and should be increased from time to time, if such increase be made necessary by the increase of the number of stills.

The attention of the Assessor to whom this bond may be offered for approval is called to the duty imposed upon him by the following provisions, contained in section 7 of the act approved July 20, 1868, to wit:—

"The Assessor may refuse to approve said bond when, in his judgment, the situation of the distillery is such as would enable the distiller to defraud the United States."

"A new bond may be required in case of the death, insolvency, or removal of either of the sureties, or in any other contingency, at the discretion of the Assessor or Commissioner of Internal Revenue."

[*Indorsement.*]

I hereby certify that this bond is properly filled up and executed, and that the sureties thereon are, in my belief, sufficient, and I approve the same.

——— ———,
Assessor ——— district of ———.

(25½.)

FORM OF BOOK TO BE KEPT BY DISTILLERS OF BRANDY FROM APPLES, PEACHES, OR GRAPES, EXCLUSIVELY.

	Time in operation.			Material used (to be stated in gallons).										No. of boilings in each still.					Brandy produc'd				Tax paid.		
Date.	Hour of commencing.	Hour of closing.	Hours worked	Apple pomace.	Peach pomace.	Grape pomace.	Cider.	Must.	Sour wine.	Wash.	Cheese.	Lees or piquette.	Other material.	No. 1.	No. 2.	No. 3.	No. 4.	Singlings produced.	Wine gallons.	Proof gallons.	Serial No. of package	Serial No. of stamp.	Dollars.	Cents.	To whom sold or delivered.
1 to 31																									

(A.)

——— P. O., ——— Co., ———.
———, 187–.

SIR:

You are informed that during the present month I will put up about ——— packages of brandy, at my distillery, No. ———, which will contain, in all, about ——— wine gallons, and which I desire to have gauged and marked by a United States gauger, as required by law and regulations, so as to enable me to make my monthly return and pay the tax thereon.

Very respectfully,
——— ———, *Distiller.*

To ——— ———, Collector ——— District of ———.

(59½.)

UNITED STATES INTERNAL REVENUE.

RETURN OF GAUGER OF BRANDY FROM FRUIT.

[To be made monthly to Assessor, Collector, and Distiller. Each package must be reported separately.]

RETURN OF BRANDY gauged at Fruit Distillery No. ———, in the ——— District of ———, operated by ———, for the month of ———, 187–.

For whom gauged.	Date of gauging.	Serial No. of package.	Wine gallons.	Wantage.	Proof.	Proof gallons.	Taxable gallons.	Tax due.	
								Dolls.	*Cts.*

——— ———,
Gauger.

(15.)

UNITED STATES INTERNAL REVENUE.

MONTHLY RETURN OF DISTILLER OF APPLES, PEACHES, OR GRAPES, EXCLUSIVELY.

Account of the quantity of brandy distilled from apples, peaches, or grapes, exclusively, by ——, in the —— of ——, county of ——, and State of ——, during the month of ——, 187–.

☞ To be furnished to the Assessor in triplicate on the first day of each month, or within ten days thereafter, and the tax to be paid to the Collector within the same time.

Date.	Time in operation.			Material used (to be stated in gallons).										No. of boilings in each still.				Singlings.			Brandy distilled.		Amount of tax.	
	Hour of commencing.	Hour of closing.	Hours worked.	Apple pomace.	Peach pomace.	Grape pomace.	Cider.	Must.	Sour wine.	Wash.	Cheese.	Lees or piquette.	Other material.	No. 1.	No. 2.	No. 3.	No. 4.	On hand 1st of month.	Produced during the month.	On hand last of month.	Wine gallons.	Proof gallons.	Dollars.	Cents.
1 to 31																								
Total																								

(Signed) —— ——.

I, —— ——, do swear that the above is an exact account of the number of hours worked and the whole number of gallons of brandy distilled at Distillery No. ——, carried on by —— ——, as aforesaid, during the month specified; and that the spirits so produced were distilled from apples, peaches, or grapes, exclusively; and that said account is, to the best of my knowledge and belief, correct and true.

(Signed) —— ——.

Sworn and subscribed before me, this —— day of ——, A. D. 187–.

(Signed) —— ——,

Assistant Assessor, —— Division, —— State of ——.

ADDITIONAL EXEMPTION IN RELATION TO BRANDY DISTILLED FROM APPLES, PEACHES, OR GRAPES, EXCLUSIVELY.

TREASURY DEPARTMENT, OFFICE OF INTERNAL REVENUE,
Washington, October 8, 1869.

SPECIAL TAX-PAID STAMP FOR FRUIT BRANDY.

IT being apparent that the interests of the government, and the necessities of the business of distillers of brandy from fruit, require further exemption of such distillers from the provisions of the law than that heretofore prescribed in Series 5, No. 7, under section 2, act of July 20, 1868, it is now ordered that they be exempted from so much of the provisions of section 23 of said act as requires them to put up the brandy they distill from fruit in casks of not less capacity than twenty gallons, wine measure, and that hereafter, until otherwise ordered, they be allowed to put up such spirits in packages of ten proof gallons or upwards.

Under the authority conferred in section 101 of said act, with a view to the better collection of the tax derivable from brandy distilled from fruit, and the further prevention or detection of frauds on the revenue, a special stamp for fruit brandy has been issued, for packages of ten gallons, with coupons attached for use on packages containing more than ten gallons and not in any case exceeding nineteen gallons, the stamp now in use still applying to all packages of twenty gallons or upwards.

Collectors will make immediate requisition for supplies of this special stamp, in the use of which the blanks must be filled in accordance with the facts in each case. The stamp will be in book form, of two sizes, the larger containing three hundred, the smaller one hundred and fifty each. A filled form of this stamp will read as follows:—

Received 8th day of October, 1869, from William Compton, tax on ten gallons proof brandy, cask No. 1, for delivery to William Compton, at his distillery in Oldham County.

Attest:
W. J. WHITE,
U. S. Gauger.

JAMES F. BUCKNER,
Collector, 5*th District*,
State of Kentucky.

C. DELANO, *Commissioner.*

Approved:
GEO. S. BOUTWELL,
Secretary of the Treasury.

INSTRUCTIONS AS TO SURVEY OF DISTILLERIES.

TREASURY DEPARTMENT, OFFICE OF INTERNAL REVENUE,
August 26, 1869.

THE survey required by section 10 of the act of July 20, 1868, is to be made of every distillery registered or intended to be registered for the production of spirits, and of every still hereafter set up and intended to be used for that purpose.

The assessor and person designated to aid him are to estimate and determine the "*true producing capacity*" of each distillery, and make report thereof in writing.

In performing this duty, they will assume that the distiller will put his machinery and apparatus in good working order, use good material, and employ competent and skilful workmen, and so manage his business as to produce the most favorable results; and the question to be determined is, what, under such circumstances, is the number of bushels of grain or gallons of molasses which can be mashed and fermented in twenty-four hours, and the quantity of spirits that can be produced in the same time.

The "*true producing capacity*" of a distillery is not limited to what the distiller may produce by following a particular course which he has marked out, but what may be produced under favorable circumstances. The distiller, for instance, may say that he will mash a certain number of bushels, and but once a day, and will use a portion only of his fermenting tubs, and will ferment his mash, for instance, ninety-six hours; but what he could produce by that process is not the "true producing capacity" of his distillery, because he could mash double the proposed number of bushels, and three or four times instead of once per day, and can ferment twice or three times as much as he states, and of course increase his product in proportion. The "true producing capacity" of such a distillery is not the amount which is so proposed to be produced, but the amount which *can* be produced, using all the machinery and apparatus, under competent and skilful management, taking as a basis for the calculation such premises as will produce the best practical results.

In order to estimate and determine "the true producing capacity" of a distillery, it is necessary to ascertain the capacity

of the mash and fermenting tubs. This should be done by actual and careful measurement, and the report must show the greatest diameter, least diameter, and depth of each tub; its form, whether round, oval, or square; its full capacity in gallons; the number of dry inches allowed for working or fermenting; its working capacity; the fermenting tubs, in gallons; the mash tubs, in bushels—estimating not less than one bushel to twenty-five gallons of mash.

The fermenting capacity, however, may limit the mashing capacity, because the distiller cannot mash more than he has capacity to ferment. If it should be found that a distiller has an excess of mash tubs, as compared with his fermenters, due regard will be had to this fact, as mash tubs may be used as fermenters.

Having ascertained the diameter and depth of each tub, the cubical contents will be found by the following rule: Multiply the square of the mean diameter in inches by the decimal .0034, and the product will be the number of gallons in one inch of depth; multiply this product by the number of inches of depth in the tub, and the product will be the cubical contents or capacity of the tub in gallons.

Having found the aggregate capacity of the fermenters, the number of bushels which it will take to fill such fermenters is found by dividing that quantity by the number of gallons of mash made from a bushel of grain. Under the provisions of section 20 this divisor cannot exceed forty-five, except in case of a distillery having a producing capacity of less than one hundred gallons in twenty-four hours, and in which grain or meal is mashed by hand, and without the use of steam, in which case it cannot exceed sixty. These are the maximum limits, and if in either case the distiller makes a thicker mash, using less water to the bushel, the divisor will be proportionately less.

Having found the number of bushels which are required to fill the fermenters, the assessor and person designated to aid him will determine what, under all the circumstances, is a reasonable period to be allowed for fermenting, and in so doing they are not bound by the period stated in the distiller's notice, but are to take such period as will, under ordinary circumstances and with good management, produce the best results. From the best information it is believed that a fermenting period of sixty hours is as long a period as can be used consistently with good management or a profitable conduct of the business, and where a greater period than this is assumed it must be accompanied with such a statement of the circumstances as will show it to be justified as an exceptional case.

Having thus determined the fermenting period, the twenty-four hours during which the fermenting tubs are to remain empty are to be added, and with this sum divide the number of bushels which it requires to fill all the fermenters, and the result will show the number of bushels that can be mashed in one hour or one day, according as the divisor is in hours or days; and if in hours, multiply by twenty-four to find the quantity for one day of twenty-four hours.

Having thus found the number of bushels which can be mashed and fermented in twenty-four hours, the next point to be determined is, what quantity of spirits can, under all the circumstances, be produced from a bushel of grain—that is, what quantity of spirits can a practical distiller, with good management, produce from a bushel of good grain; and while no fixed rule can be laid down on the subject, it may be suggested that in ordinary distilleries this varies from three to four gallons, and in some cases over four gallons, as shown by the returns, or an average of three and a half gallons to the bushel.

It may be safely assumed that it would require a strong case to justify an estimate of less than three gallons, and in such case the reasons for such an allowance must be fully reported to the Commissioner; and in all cases where the estimate is below the average (three and a half gallons) an explanation will be required. Having determined this product, multiply the number of bushels that can be fermented in twenty-four hours by it, and the result will be the quantity of spirits that can be produced in twenty-four hours.

The capacity of a molasses distillery is estimated upon the same principle. Having found the working fermenting capacity of the fermenters in gallons, as above stated, divide this by the number of gallons of mash which the distiller makes from a gallon of molasses, not exceeding seven gallons of mash for a gallon of molasses, and it will give the number of gallons of molasses required to fill the fermenters. Take the fermenting period, plus the twenty-four hours, and divide the amount found as above, and it will give the quantity which can be fermented in twenty-four hours.

The quantity of spirit which can be produced from a gallon of molasses varies, of course, with the completeness of the apparatus and the quality of the material, from eighty to ninety-five per cent.—from eighty-five to ninety per cent. probably being a fair average; and in no case should a less allowance than this average be made without first submitting a full report of the reasons therefor to the Commissioner.

In case any question arises as to the correctness of the survey, the assessor will forward a draught of his report to the Com-

missioner before it is signed, in order that such questions may be determined.

In estimating the number of dry inches to be allowed for fermentation, the assessor and person designated to aid him must, of course, be governed in a great measure by the depth of the fermenting tubs. From the best information received, it is believed that a fair allowance will be from three to seven dry inches for corn, and any mixture of corn and rye not exceeding one-half rye to one-half corn; and from seven to twelve dry inches for rye, and any mixture of rye exceeding one-half. While it is perhaps natural that the distiller should claim the maximum allowance as most advantageous to him, it is incumbent upon the officers making the survey to make such allowance only as is fair and equitable, having regard to the interests of the government as well as of the distiller. Should the allowances in any district in all cases equal the maximum allowance, or in most cases exceed the average between the two extremes given, the survey should be accompanied by some explanation of the reasons therefor, to rebut the inference which might be drawn from such action.

Under the provisions of section 6, the distiller is required to state the fermenting period which he proposes to use, and the quantity of spirits which he will produce. This may or may not be the "true producing capacity" of his distillery; but having so stated it, he cannot change his fermenting period without notice to the assessor, as provided in said section; if he does, he renders himself liable to heavy penalties. This is his own statement, entirely distinct from and independent of the "true producing capacity" as estimated and determined under section 10. It is to be made and filed before any action is taken under section 10. If, after his true producing capacity is determined under section 10, he chooses to adopt a fermenting period corresponding to that assumed by the assessor and person designated to aid him, he may do so by giving the proper notice. If he does it without such notice, he subjects himself to penalties.

As this estimate and determination of the true producing capacity of distilleries is one of the most important tests by which the amount of tax to be paid by a distiller is to be determined, it should be carefully and correctly made, and the officers required to make it will be held to a strict accountability.

The instructions on pages 7, 8, and 9, of Series 5, No. 7, in relation to the survey of distilleries, are hereby revoked, and the foregoing substituted therefor. Officers receiving these instructions will attach the same to Series 5, No. 7.

C. DELANO, *Commissioner.*

REGULATIONS AND INSTRUCTIONS RELATIVE TO TICE METERS.

TREASURY DEPARTMENT, OFFICE INTERNAL REVENUE,
Washington, March 30, 1869.

I. AS TO PROCURING AND ATTACHING METERS.

ON the 16th of September, 1868, the Commissioner of Internal Revenue adopted and prescribed for use in distilleries the spirit-meter invented by Mr. Isaac P. Tice, of New York, being the same that was adopted and prescribed by the Hon. Secretary of the Treasury on the 19th of April, 1867, under section 15 of the act of March 2, 1867, and subsequently recommended for use by the commission appointed under the joint resolution of Congress approved February 3, 1868.

Section 3 of the act of July 20, 1868, provides that whenever the Commissioner of Internal Revenue shall adopt and prescribe for use any meter, every owner, agent, or superintendent of a distillery must furnish and attach, at his own expense, such meter for use at his distillery, and furnish all pipes, materials, labor, and facilities necessary to complete such attachment in accordance with the regulations of the Commissioner of Internal Revenue, who is also authorized to order and require such changes of, or additions to, the distilling apparatus, connecting pipes, pumps, or cisterns, or any machinery connected with or used in or on the distillery premises, and prescribe such fastenings, locks, and seals as he may deem necessary.

The system which has been adopted involves the use of two meters; the first will be attached to the end of the worm and will register the entire product of the still; the second will be placed upon the doubler in such position as to register the quantity of low wines carried back to the doubler for redistillation. If the still is provided with such attachments that no low wines are discharged, and the distiller is prepared to report as taxable the entire product of the still, the second meter will not be required.

These meters are constructed of six different sizes, the prices and capacities being as follows:—

Sample meter A $200
Capacity, four gallons per minute.
Sample meter B 250
Capacity, eight gallons per minute.
These are intended for attachment to small copper stills.

Meter No. 2 600
Capacity, three gallons per minute.

Meter No. 3 800
Capacity, six gallons per minute.

Meter No. 4 1000
Capacity, eighteen gallons per minute.

The capacity above given must be understood to be the maximum capacity per minute of each of the meters. Meter No. 1 is not now made, having been found too small for practical use; a larger size, No. 5, having a capacity of about 30 gallons per minute, is now being constructed, the price and exact capacity of which will be announced hereafter.

The meter adopted being the invention of Mr. Tice, and secured to him by letters patent, can only be made by him or under his license; and in order to guard against an unreasonable price being demanded of those who are bound by law to purchase it, the prices of the several sizes, under an arrangement made between Mr. Tice and the government, were determined by a committee, consisting of Wm. T. Duvall, of Georgetown, D. C., Wm. P. Trowbridge, of New York, and S. J. Knowles, of Massachusetts, all practical and skilful machinists, two of whom were designated by the government and one by Mr. Tice, and the sums hereinbefore named are the prices agreed upon by them for the meters delivered at the place of manufacture, as stated in the report of that committee.

Under the provisions of section 3 of the act of July 20, 1868, distillers are required to procure and attach such meters, and in making their applications therefor they must state the capacity of the still in cubic feet, and its utmost possible producing capacity per minute—that is, the greatest possible quantity of spirits that will pass from the worm in that time. The producing capacity here referred to must not be confined to high wines merely, but must show the entire quantity of spirits, whether high or low wines, which can or will pass from the worm in the time specified. The attention of distillers is especially called to this point, as the discharge from the worm is not uniform, and if the meter is not of sufficient capacity to measure and pass the largest quantity which the worm will discharge it will be flooded, and its operation thereby stopped

until the meter is opened and the valve again placed in working order.

The application must also show the cubic contents of the doubler, the outside diameter of the worm at its lower extremity, the height and diameter of the tank in which it is placed, and the material of which the still, doubler, and tank are constructed. The diameter of the main pipe leading from the still to the doubler, as well as of the charging and discharging and blow-off pipes, including the pipe used for discharging the doubler, must also be given. There is also required a description of the foundations upon which the still, doubler, and condenser are respectively supported. If the still is provided with collapse valves, their number and diameter must also be stated.

This application will be made on Form 7, as heretofore prescribed, which will be furnished by the collectors of the several districts. At the time of making the application, the applicant will furnish to the collector of his district a certificate of deposit in a United States depository for the amount of the price of the meter or meters, payable to the order of Mr. Tice, and the collector will certify upon such application that he has received such certificate, and forward the application to this office for transmission to Mr. Tice. And the applicant should also state the means of access to the distillery, whether by railroad, steamboat, or canal, and with what points the distillery is connected by either of these modes of communication. If there is any person carrying on the trade of coppersmith in the immediate vicinity, the collector will state the fact; and if not, he will state the distance to the nearest point at which the services of such artisan can be procured. Upon the receipt of the bill of lading, the collector will at once transmit the certificate of deposit to Mr. Tice, at his address, 314 Third avenue, New York city.

The expenses of transportation and attachment of the meters, and of any changes required to be made in the distillery, are to be paid by the distiller.

The distillers must furnish all lumber and other materials necessary for the attachment of the meter, and such workmen and assistants as may be required. The attachment will be made in such manner as to interfere as little as possible with the operation of the distillery; but in case the distiller neglects promptly to provide the materials and assistance required, or in any way attempts to delay or defeat the attachment, it will be the duty of the collector of the district to close the distillery until the meters are attached.

Where meters are being attached to several neighboring distilleries at the same time, the expenses incurred by Mr. Tice and his employees will be apportioned among the several distilleries according to the time employed in each.

Distillers of apples, peaches, and grapes, exclusively, are exempted from the provisions of law requiring distillers to procure and attach meters.

Examination of the applications on file has shown that the meters applied for by distillers are in many cases of too small capacity for the distillery.

It is well known that, in steam distilleries especially, stoppages frequently occur for a short time when the accumulated force of the steam drives over the alcoholic vapor, which is rapidly condensed and discharged from the worm with great force, in some cases accompanied by mash; and the question for the distiller to determine under this regulation is, what is the greatest quantity which will be discharged from the worm under such circumstances? If the meter is not sufficient to pass the product of the worm under any and all circumstances, it will be flooded, the discharge valve closed, and its operations stopped, the spirit filling the meter and flowing back into the worm. The effect will of course be the same as if the distiller should effectually close the outlet of the worm while the still is in operation.

If the distiller applies for a meter of too small capacity, its attachment will be attended with the result above stated, unless prevented by shutting off the steam in time. The cost of the delay and other expenses attending such an accident may be much more than the difference in the cost of the meters, aside from the fact that the distiller in such case would be compelled to procure a larger meter to prevent a recurrence of such accidents.

By the third paragraph of Circular No. 69, distillers were required to procure and attach two meters in all cases, except where the still is provided with such attachments that no low wines are discharged, and the distiller is prepared to report as taxable the entire product of his still. In most of the applications but one meter is called for, although there is in the distillery a separation of low and high wines. If the two meters are attached, the distiller will be charged with the amount shown by the meter attached to the worm, deducting therefrom the amount of low wines shown by the other meter to have been returned to the doubler.

Distillers should be at once required to revise their applications for meters, and where the meters are too small, or only

one is applied for when two are required, the applications should be at once corrected. If not so done, it will be understood that the distillers propose to stand upon their applications as made, and that they will take the entire responsibility as to the meters ordered by them being of sufficient capacity; and, where only one meter is applied for, that they assent to being taxed for the low as well as the high wines. All revenue officers will govern themselves accordingly. The manufacturer of the meters will be instructed to forward the meters of the sizes applied for, and to attach the same; and if any trouble arises on this account, the distiller, having been furnished with the precise size he asked for, will have no reason to complain of any one but himself.

Meters will now be delivered as fast as the corrected applications are received, and the manufacturer will proceed with their attachment as fast as possible. Collectors should at once notify all distillers who have not made application to do so immediately, and will report to the Commissioner the names of such as refuse or neglect to make such application. Whenever a certificate of deposit is forwarded to Mr. Tice, the collector will report the fact to this office, giving the amount, and name of the distiller who made the deposit.

Where collectors deposit their collections in a depository bank, the meter deposits will be made in such bank; but where they are required to deposit collections with an assistant treasurer or designated depositary, the meter deposits will be made in some responsible bank.

A daily report must be made by the storekeeper in charge of each distillery to the assessor of the district, setting forth the indications shown by the meter at the hour of 12 midnight, or at the time when the distillery ceases to operate for the day. And each assistant assessor who has a distillery in his division will examine each meter whenever he visits the distillery, and report to his assessor the indications of the meter as above directed. And assessors, in making their monthly computation on Form No. 89, will use the information thus given in determining the production. Where but one meter is attached, they will charge the distiller with the full product of the worm, making no deduction for low wines returned to the still or doubler.

In distilleries where the product of the first distillation is singlings only, no meter will be required for the singling still; but each doubling still will require one or two meters, depending upon the fact whether there is a separation of the low wines.

It must be understood, however, that there must be close connections between the singling and doubling stills in all cases,

so that no access can be had by the distiller to the low wines at any point during their passage from the singling to the doubling still.

Collectors will furnish distillers promptly with a copy of these instructions, and if no corrections of the applications are made, will at once notify this office.

Where distillers continue to run, after the issue of these instructions, without making prompt application for a meter, the names of such distillers will be at once reported to this office.

Under the provisions of the law the distiller is required to furnish and attach meters at his own expense, and also to furnish all pipes, materials, labor, and facilities necessary to complete such attachment. The first duty of a distiller is, of course, to procure a meter. The manufacturer is not required to furnish the meters on credit, and ought not to be expected to do so. When he ships a meter to a distiller, in accordance with the application, the manufacturer is entitled to the pay for it. The law does not require the manufacturer to attach it, but, on the contrary, requires the distiller to attach at his own expense. Wherever changes are required in a distillery to facilitate the attachment, such changes must be made by the distiller. In order that the attachment may be made correctly and the meters properly adjusted, the manufacturer or some of his own workmen are required to superintend the attachment. When a distiller is notified by the manufacturer or his agents what changes are necessary, and what materials or assistance are required, he should furnish them promptly. It will be the duty of collectors to see that they do so, and in case of any unreasonable delay, to close the distilleries until the attachment is completed.

Wherever it is practicable an officer detailed by the Commissioner will supervise the attachment, and when no such detail is made the assessor will detail one of his assistants for that purpose. When the attachment of a meter is completed, it must be promptly reported to this office by such officer or assistant assessor. The presence of such officer, however, will not be understood as relieving either the collector or assessor of the district from the responsibility properly belonging to them.

A strict compliance with these instructions will be required of all officers of internal revenue. Whenever the manufacturer or his agents commence the attachment of meters in any district, the officers of such district are required to afford them every aid in their power, in order that the work may be completed as soon as possible. If there is any delay on the part of the distiller, or if any obstacles are interposed by him, or

the manufacturer or his workmen fail to do their duty, prompt report must be made to this office.

All must understand that the requirements of the law in relation to meters and their attachment will be rigidly enforced.

II. Computation of quantity of proof spirit.

There are two classes of these spirit meters made. In one of these all the liquor is weighed, and a small sample of each can-full reserved for future inspection. In the other class all the liquor is likewise weighed, and, besides, the volume and weight of a certain portion of it is registered, from which the proof can be computed; in addition to which a small sample is taken, which serves to verify the proof deduced from the automatic register, and affords the means of applying a correction for temperature.

The first class, or *sample meters*, are made of two sizes, marked A and B. The former weighs five pounds, and the latter ten pounds, at one registration. To ascertain at any time how many proof gallons have run through one of these meters since a previous inspection, read the index, withdraw *all* the reserved sample, and ascertain its strength by the hydrometer in the usual way. Subtracting the previous reading of the register from that now observed, and multiplying the difference by five for sample meter A, or by ten for sample meter B, we find the number of pounds of liquor that have been run through the meter. Having now the number of pounds and the average proof, we turn to Table II. of the *Manual for Gaugers*, which gives the corresponding number of gallons. The number of *proof gallons* is then found in the usual way by multiplying the number of gallons with the per cent. of proof spirits contained in them.

METER REPORT.

Example.—From meter at M. N.'s distillery at (here insert locality). Sample meter A. Amount of spirits distilled, as shown by meter, from February 6th, at 9 o'clock A. M., to February 13, at 4 o'clock P. M.:

Reading of register .	5910	
Previous reading . .	4632	
	1278	Sample drawn:
	5	Hydrometer, 106; temperature, 50°.
Pounds registered . .	6390	True per cent., 110.
Total gallons . .	830	Total proof gallons, 913.

The number of gallons passed through are here found from Table II. of the manual, as follows: On the line for 110 per cent. we find that 600 pounds are equal to 77.92 gallons, and hence 6000 pounds give 779.2 gallons; also 300 pounds give 38.9 gallons; and 90 pounds give 11.7 gallons; therefore 6390 pounds give 829.8 gallons.

For the 90 we look in the column 900, and shift the decimal point one figure to the left.

The second class, or *complete meters*, are made of four different sizes, marked respectively No. 2, No. 3, No. 4, and No. 5. In each meter the lower register counts every discharge of a weighing-can into which all the liquor runs. At each discharge this can weighs—

In No. 2, 5 pounds.
In No. 3, 10 pounds.
In No. 4, 30 pounds.
In No. 5, 50 pounds.

The discharge of this weighing-can, at the same time empties a measuring-can holding exactly a quart, and the spirits so emptied are weighed in a three-pound weighing-can which is registered on the upper register; the number of quarts being taken from the lower register, as well as the total weight of the spirits. That portion of the spirits which was reserved in the measuring-can passes, after being weighed in the three-pound can, into the large or lower weighing-can. The quart and three-pound cans are alike in all the sizes of meters.

We obtain thus the whole weight of the spirits that have passed through the meter, and also the weight of a certain number of representative quarts, from which we can find, by appropriate tables, the strength and quantity, and consequently the number of proof gallons. It is convenient to convert the quarts into gallons, as the tables have been constructed for that unit. (See Table IV. of the Manual for Gaugers.)

Example.—Suppose that since the previous reading the lower register of a No. 3 meter has counted 636, and the upper register 398; we learn that 6360 pounds of liquor have passed, and that 636 quarts, or 159 gallons of it, weighed $3 \times 398 = 1194$ pounds. Dividing 1194 by 159, we find that each gallon weighed, on the average, 7.51 pounds. Then dividing the whole weight, 6360 pounds, by the average weight of 1 gallon, 7.51 pounds, we find the whole run to have been 846.8 gallons. For the strength we enter Table IV. of the manual with 751 in the left-hand column, and find 130.6 as the corresponding percentage of proof spirits. Hence adding to 846.8 gallons 30.6 per cent. we obtain 1105.9 proof gallons for the value of the registered spirits.

To a still which produces only high wines a single meter will be attached, and the foregoing process gives the number of proof gallons on which the tax is to be assessed. But if the still produce both high and low wines, the latter being returned to the doubler for redistillation, then an additional meter will be attached at the doubler, on which the low wines will be registered. We can then compute from the indications of this low-wine register the proof gallons returned to the still, which are to be deducted from the gross amount shown by the meter at the worm, in order to ascertain the amount on which the tax is to be assessed. Suppose, for example, that in the previous case the low-wine meter had counted on the lower register 359, and the upper one 229; we see that 3590 pounds of spirit were sent back as low wines, and that 359 quarts or 89.75 gallons of it weigh $3 \times 229 = 687$ pounds. Dividing 687 by 89.75, we find that each average gallon weighed 7.66 pounds, and seeing how often this is contained in 3590, that there were 468.7 gallons. Moreover, looking for the per cent. corresponding to 766 in Table IV., we find 114.6 per cent. as the average strength of the low wines. Hence 537.2 proof gallons have been sent back as low wines, which, subtracted from the total proof gallons that passed through the meter at the worm, viz., 1105.9, leaves 568.7 proof gallons as the amount on which the tax is to be assessed.

If it be desired to know the average strength of the high wines, in order to compare with the gauger's return, that may be easily obtained by comparing the actual or "wine" gallons with the proof gallons, as thus: deducting 468.7, the number of gallons of low wines, from 846.8, the total number of gallons distilled, we find 378.1 the number of gallons of high wines, which have been found equivalent to 568.7 gallons of proof spirits. Dividing the latter number by the former, we obtain 150.4 per cent. as the average proof of the 378 gallons of high wines produced.

The foregoing calculations all suppose that the liquor has been measured in the meter at a temperature of 60° Fahrenheit, for which the tables are constructed.

If the spirits had passed through the meter at a high temperature, the proof derived from its indications would be higher than the actual strength; and if at a lower temperature, it would be lower than the actual strength, in precisely the same degree as if the proof had been taken by a hydrometer.

The receiver in which the small samples are collected contains a hydrometer and thermometer exposed to view. By these the average strength of the spirits distilled since the receiver was last emptied can be ascertained by observation,

and their indications should be recorded at each reading of the meter. The proof so obtained should not differ from that derived from the automatic register by more than what is due to the difference between 60° Fahrenheit and the temperature at which the spirits may have passed through the meter.

The receiver should be emptied after the verification of each report of the indications of the meter.

The following form, adapted to the various cases, will be used in making reports of the indications of meters. The names, dates, and figures are filled in with the pen, and constitute an actual report, the computation of which is given below:—

METER REPORT.

From meters at Mr. ——— ——— distillery, at ———.

Amount of spirits distilled as shown by meters, from **February 11, at 9 o'clock A. M., to February 12, at 2 o'clock P. M.** :—

Meter No. **4**, *at Worm.*

Top register	**3842**	Bottom register . . .	**4220**
Previous indication . . .	**3296**	Previous indication . . .	**3325**
Difference	**546**	Difference	**895**

Total number of wine gallons distilled 3668
Average proof 149 per cent.
Total number of proof gallons 5465

Meter No. **4**, *at Doubler.*

Top register	**1029**	Bottom register . . .	**2111**
Previous indication . . .	**717**	Previous indication . . .	**1611**
Difference	**312**	Difference	**493**

Number of wine gallons of low wines **1954**
Average proof 122 per cent.
Number of proof gallons of low wines **2384**
Total number of proof gallons run, minus low wines redistilled, by meter **3081**

Sample Receivers.

Meter at Worm.	*Meter at Doubler.*
Hydrometer **145**; temperature **68°**; proof **142.**	Hydrometer **118**; temperature **65°**; proof **116.**
Bottom register **895**	Bottom register **493**
30 pounds.	**30 pounds.**
26,850 pounds.	**14,790 pounds.**
Total gallons **3,631** (by Table II.)	Gallons of low wines . . **1,934**
Total proof gallons . . **5,156**	Proof gallons low wines . **2,243**

Total proof gallons run, minus low wines redistilled, 2913.
Tax due on 2913 proof gallons.

The computations may be conveniently made as follows:—

Meter at Worm.

```
Bottom—               Top—
  4)895 quarts.        546
    ———————              3
   223.75 gallons.    ————
                      1638 pounds.

 223.75)1638.00(7.32
        1566.25
        ———————
          71.750
          67.125
          ——————
           4.6250
           4.4750
          ———————
            .1500

     895 (lower weighing can.)
      30 pounds.
     ————
7.32)26850.00(3668 galls. of 149 proof.
     2196     1467.2
     ————      330.12
     4890     ———————
     4392     5465.32 proof gallons.
     ————
      4980
      4392
      ————
       5880
       5856
       ————
         24
```

Meter at Doubler.

```
4)493               312
  ———                 3
  123.25 gallons.  ————
                    936 pounds.

  123.25)936.00(7.594
         862.75
         ——————
          73.250
          61.625
          ——————
          11.6250
          11.0925
          ———————
            .53250

      493
       30
     ————
7.594)14790.000(1954 galls. of 122 pr'f.
      7594        390.8
      ————         39.08
      7196.0      ———————
      6784.6      2383.88 proof galls.
      ——————
       411.40
       379.70
       ——————
        31.700
        30.376
        ——————
         1.324
```

The above gives the quantity and proof from the meter indications, which would be accurate if the spirits had been measured at 60° Fahrenheit. But by the sample received we see that the true proof was 142 and 116 per cent. respectively. The difference of 7 and 6 per cent. corresponds to temperatures of 80° and 75°, which are reasonable and usual. The computation of the proof gallons on which the tax is due is made from the weight and proof by samples according to Table II. of Manual.

III. Testing meters when attached to a distillery.

The most reliable way is to ascertain *the weight* by actual weighing, and by testing with the hydrometer *the strength* of a considerable quantity of spirits, both high and low wines, discharged from the meter, and compare the same with the registration on the meter.

To this end it would be necessary to disconnect the discharge-pipes for high and low wines, and to let the spirits be run into tanks provided for the purpose, sufficiently large to receive the product of a charge of high and low wines respectively. Each tank should be mounted on a platform scale, and means provided to empty the tanks into the receivers between the runs of the still.

The weighing is preferred to measuring, because the weight is not changed by heat, while the volume is.

After weighing each tank, its contents should be well stirred and then proofed with the hydrometer; the actual indication and temperature being set down, together with the weight and the corresponding index readings of the meter.

Not less than 500 registrations of the weighing-can should be used in the test.

This will give an accurate and correct test of the *rate* of the meter.

A less accurate test may be made by comparing the result of the meter indications with the quantity and strength of the spirits actually delivered into the receiving cisterns for high wines.

In adopting this method, the officer making the test must assure himself that there is no communication with the receiving cisterns except that from the meter, and that the receiving cisterns are empty when he commences the test.

He should measure *all* and *none but the spirits* that have passed through the meter and been delivered during his test.

He will record the index readings of the meter at the commencement of the test and at the close of each run of the still, and draw off, measure, and test the proof of the spirits delivered into the receiving cisterns during each run.

The measuring may be done by means of sealed gallon or five-gallon measures, or by barrels, the capacity of which has been ascertained by actual measurement with sealed measures, or by weighing the water they will hold, allowing 12 gallons for 100 pounds.

The officer should see to the measurement personally, as well as to obtaining the average proof of each run.

C. DELANO,
Commissioner.

REGULATIONS

IN RELATION TO

THE USE OF STAMPS FOR DISTILLED SPIRITS, THE ISSUE OF STAMPS FOR RECTIFIED SPIRITS, AND TO PROVIDE FOR A UNIFORM AND CORRECT MODE OF MARKING AND BRANDING CASKS OR PACKAGES OF SPIRITS.

TREASURY DEPARTMENT, OFFICE OF INTERNAL REVENUE,
Washington, August 20, 1869.

I. USE OF STAMPS.

UNDER the provisions of the act of July 20, 1868, as amended by the act of April 10, 1869, there are, exclusive of the stamp for stock on hand, three classes of stamps for distilled spirits: 1. Those used for distillers, consisting of the distillery-warehouse and the tax-paid stamps. 2. Stamps for rectified spirits, to be used for rectifiers. And 3. Wholesale liquor-dealers' stamps, to be used for wholesale liquor-dealers.

All spirits produced are required to be deposited in the distillery warehouse, prior to which they must be drawn into casks containing not less than twenty wine gallons each, and gauged, and the distillery-warehouse stamp affixed to each cask. When withdrawn from warehouse the tax-paid stamp must also be affixed, and both of said stamps must remain upon such casks until the spirits therein are emptied or drawn off, when such stamps, with the other marks and brands, must be effaced and destroyed, as required by section 43.

The special brand, however, which, under the provisions of section 25, is to accompany the tax-paid stamp, must not be removed and destroyed, but, when the cask is emptied, is to be cancelled by cutting or burning a cancelling line across the letters and figures composing such brand in such manner as not to destroy their legibility.

The original packages of a distiller, after removal from warehouse, must, therefore, bear the distillery-warehouse and tax-paid stamps.

The absence of these stamps from any cask of raw spirits, high wines, or spirits withdrawn from a distillery warehouse,

is evidence that there has been a change of package, and the cask in such case must bear the marks and brands required by section 47, which furnish the means for identifying the spirits after such change of package. So long as the original package remains unchanged, and bears the distillery-warehouse and tax-paid stamps, no other stamp is required.

Under the provisions of section 25, every package of rectified spirits filled for shipment, sale, or delivery on the premises of any authorized rectifier, must be gauged, inspected, marked, and branded as hereinafter provided, and have affixed thereto the stamp for rectified spirits. *It must be understood, however, that the term rectified spirits is here used in its legal, and not in the ordinary commercial signification of the term. Any person who purchases tax-paid spirits and redistills or compounds the same, or who purifies or refines such spirits by any process, is a rectifier as defined by law; and the spirits so redistilled, compounded, refined, or purified, are rectified spirits, and must bear the stamps for rectified spirits. The term rectifier, as used in these regulations, includes every person who treats distilled spirits by any of the processes the using of which would constitute him a rectifier as defined by section* 59 *of the act of July* 20, 1868, *as amended by the act of April* 10, 1869.

When a rectifier purchases spirits and proposes to subject them to any of the processes which would constitute him a rectifier, he must file with the collector the notice hereinafter provided for; and, upon emptying the casks, he must erase and destroy the stamps, marks, and brands upon such casks, with the exception of the special brand accompanying the tax-paid stamp, which must be cancelled as hereinbefore provided. And when he puts spirits into casks, after completing his process, such casks must have affixed the stamp for rectified spirits, and this stamp must not be removed until the cask is emptied. The absence of this stamp from a cask of rectified spirits is evidence of a change of package, and will justify a seizure if the package is not marked and branded as required by section 47; but so long as the original cask remains unchanged, no other stamp is required.

A wholesale liquor-dealer is defined to be any person who sells or offers for sale spirits in packages of five gallons and upwards; and every cask or package filled for shipment, sale, or delivery, on the premises of any wholesale liquor-dealer, must be gauged and inspected, and have affixed thereto the wholesale liquor-dealers' stamp.

Where a wholesale liquor-dealer or rectifier purchases spirits in the original packages as put up by a distiller or rectifier, properly marked and stamped as such, no regauging or restamp-

ing is required. Where, however, he draws spirits from such original packages, and fills other packages on his premises, the spirits must be regauged and the stamps for rectified spirits or a wholesale liquor-dealers' stamp affixed, as the case may be; and if such package contains ten gallons or more, it must also be branded and marked as required by section 47. Where a wholesale liquor-dealer purchases packages of spirits properly marked, stamped, and branded, and sells them in the same condition, no other stamp or mark is required.

A neglect or failure to comply with the requirements of section 25, on the part of a rectifier or wholesale liquor dealer, renders him liable to the forfeiture of all spirits owned by him or in which he has any interest, and to a penalty of one thousand dollars.

The attention of all officers of internal revenue is specially called to these instructions, as much confusion has arisen in consequence of the indiscriminate use of the stamp for rectified spirits and the wholesale liquor-dealers' stamp. The use of the wholesale liquor-dealers' stamp upon the original packages of rectified spirits put up by a rectifier is improper, and must not be allowed; and the term rectified spirits must not be limited to its old commercial sense, but must be construed to cover all spirits included in the statute definition.

The provisions of section 47 apply to all cases where distilled spirits are drawn from any cask or package, and placed in any other cask or package containing not less than ten gallons, and intended for sale, without regard to the person by whom, or the place where, such change is made; and the absence of such marks or brands is declared to be sufficient cause of forfeiture.

All distilled spirits on hand November 1, 1868, and intended for sale, not then in bonded warehouse, were required to be returned to the collector, and stamped with the stock-on-hand stamp; and such spirits not so stamped were liable to seizure and forfeiture after December 1, 1868. Where packages of such spirits were properly stamped, and marked under the provisions of section 57, no other stamp, mark, or brand is required so long as such package remains unchanged. The absence of any stamp or brand required by law from any package of spirits containing more than five gallons works a forfeiture of the package and contents.

This provision of section 57 is not in conflict with, but in addition to, the requirements of section 25.

If any authorized rectifier fills any package with rectified spirits on his premises for shipment, sale, or delivery, without causing the same to be gauged and stamped with the stamp for

rectified spirits; or if any wholesale liquor-dealer fills any cask or package of distilled spirits without causing the same to be gauged and stamped with the wholesale liquor-dealers' stamp, he becomes liable to the penalty imposed by section 96, and to the forfeiture of all spirits owned by him or in which he has any interest; and if such packages exceed five gallons, they also become forfeited.

The local officers will be held responsible for the strict enforcement of all the provisions of the law in relation to this subject.

It is known that in some cases the wholesale liquor-dealers' stamp has been erroneously attached where the stamp for rectified spirits should have been used, under the direct instructions or with the assent and permission of the collector of the district; and packages of rectified spirits are now on the market, stamped with the wholesale liquor-dealers' stamp, without the brands and marks required by section 47, and some seizures have been made of such spirits for the want of those brands. It is not proposed that an indiscriminate seizure or detention shall be made of all such spirits for this cause, but that seizures should be confined to cases where there is other evidence of a change of package in cases where the stamps have been attached prior to these instructions. Hereafter, however, the instructions in these regulations will be rigidly enforced, and any wrongful use of stamps will be at the peril of the owner.

Circular No. 76 is revoked, and the foregoing substituted therefor.

II. Issue of stamps for rectified spirits.

Whenever any rectifier proposes to empty any spirits for the purpose of rectifying, purifying, refining, redistilling, or compounding the same, he will file with the collector a notice or statement giving the number of casks or packages, the serial number of each, the number of wine and proof gallons in each, the kind of stamps and serial number of each, the particular name of such spirits as known to the trade, the proof, by whom produced, the district where produced, by whom inspected, and the date of inspection.

This notice will be in the following form :—

To ——— ———,
Collector ———, district of ———.

Notice is hereby given that I will empty for the purpose of rectification (redistilling, or compounding, as the case may be) the following described packages of distilled spirits, to wit: ——— barrels, upon which are the following stamps, marks, and brands :—

Serial number cask.	Wine gallons.	Proof gallons.	Proof.	Serial number warehouse stamps.	Serial number tax-paid stamps.	Name of spirits.	By whom produced.	District where produced.	Date of original gauge.	By whom gauged.
93	40	54	135	29101	65267	High wines.	Smith & Co.	6th. Ohio.	May 1, 1869.	John Smith.

Containing in the aggregate ——— proof gallons.
Dated ——— ———, 18—.

——— ———, Rectifier,
No.—— ——— street.

When the process of rectification (including compounding, &c.) has been completed, the rectifier will so notify the collector, giving the number of proof gallons so rectified, redistilled, or compounded, and request that the spirits may be gauged and inspected and stamps issued for the same; and thereupon the collector will direct a gauger to gauge and inspect the same, and will issue stamps for rectified spirits covering the quantity of spirits, but not in any case to exceed the number of proof gallons stated in the notice of the rectifier as filed in his office. These notices will be preserved and filed by the collector, and a copy thereof furnished to the assessor, who on the first of each month will compare the same with the return of the rectifier.

Collectors will in no instance issue stamps for rectified spirits to any rectifier until this notice is filed with him, and such stamps will be delivered to the gauger, who will attach the same to the barrels or packages.

III. Marking and branding of casks or packages of distilled spirits.

Under the authority vested in the Secretary of the Treasury and the Commissioner of Internal Revenue, by the provisions of the act of July 20, 1868, the following regulations are prescribed for the purpose of securing a uniform and correct system of marking and branding packages of spirits:—

1. *Raw Spirits.*

The term "raw spirits" must be understood as including all spirits in the state in which they are produced by the distiller, all of which must be entered in the distillery warehouse, and

duly withdrawn therefrom upon the payment of tax, and which should, except in cases where there has been a change of package, bear the distillery-warehouse and tax-paid stamps.

When such spirits are drawn from the receiving cisterns they must be gauged, proved, and marked, and in addition to affixing the distillery-warehouse stamp the gauger must cut upon the bung-stave in a legible manner the number of wine gallons, the proof, and number of proof gallons of spirits contained in each cask. At the same time the gauger will cut with a die, or burn upon the head of each cask, its serial number in figures not less than one inch in length, and the serial number of the distillery-warehouse stamp in figures not less than half an inch in length, placing the same immediately under the serial number of the cask, as follows:—

No. 194.
D. W. S. No. 47946.

When withdrawn from warehouse each cask must, in addition to the tax-paid stamp, have cut or burned upon it the name of the distiller, the district, the date of the payment of the tax, the number of proof gallons, and the number of the tax-paid stamp. This brand may, in accordance with the present regulations, be abridged in the following manner:—

John Smith & Co.,
Distillers,
6th Dist. O.
T. P. Jan. 10, 1869, P. G. 44.
Stamp 39857.

All of this, except the date, number of proof gallons, and number of the stamp, may be burned upon the cask prior to its being filled at the cisterns, and the date and numbers cut with a die at the time the tax-paid stamp is attached. The letters and figures constituting any brand or mark must in no case be less than half an inch in length. In addition to this, the cask must be conspicuously marked or branded with the particular name of the spirits as known to the trade, as "high wines," "rye," "Bourbon," or "copper distilled" whiskey, as the case may be.

When it becomes necessary to change a package in a distillery warehouse, *i. e.*, to draw off the contents of a cask bearing the distillery-warehouse stamp and the accompanying marks and brands, and to place the same in a new cask, the spirits must be again inspected and gauged, the number of wine and proof gallons must be cut upon the bung-stave and upon the head of each cask; the gauger will cut with a die or burn with

a branding-iron his name and office, the time and place of inspection, the proof of the spirits, the name of such spirits as known to the trade, the name of the distiller, the distillery where such spirits were produced, and the serial number of the original package, together with the serial number of the warehouse stamp. This brand may be in the following form :—

Thomas P. Smith,
U. S. Gauger, 1st Dist. Pa.
Insp. May 1, 1869, dist. warehouse, No. 10,
High wines, proof 140.
Richard Roe, distiller.
Distillery No. 10, 1st Pa.
From cask No. 193.
D. W. S. 40949.

Where such change of package is made after the spirits have been withdrawn from warehouse and the tax-paid stamp attached, the cask will be marked and branded in the same manner, with the addition of the number of proof gallons, the date of the payment of the tax, and the serial number of the tax-paid stamp. This brand may be substantially as follows :—

Thomas P. Smith,
U. S. Gauger, 1st Dist. Penna.
Insp. May 9, 1869,
For Scott & Co., wholesale liquor dealers,
10 Water St., Philada., Pa.
Rye whiskey, proof 101.
John Smith & Co., distillers,
Distillery No. 6, 6th Dist. Ohio, P. G. 44.
T. P. May 1, 1869, stamp 39857.
From cask No. 901, D. W. S. 49129.

2. *Rectified Spirits.*

Under the name rectified spirits are included all spirits which, after leaving the hands of the distiller, are leached through coal, redistilled, refined, compounded, or subjected to any process which would constitute the person using it a rectifier as defined by law.

Spirits subjected to any of these processes must be put up in casks, inspected and gauged, and in addition to attaching the stamp for rectified spirits the gauger will cut upon the bung-stave the number of wine and proof gallons, and mark upon the head of each cask, with a stencil-plate, in durable ink, his name and office, the date of inspection, the particular name of such spirits as known to the trade, the proof, the name and place of

business of the rectifier, and the serial number of the stamp for rectified spirits affixed thereto. This mark or brand may be substantially as follows:—

Thomas P. Smith,
U. S. Gauger, 1st Dist. Penna.
Insp. May 15, 1869.
Rye whiskey, proof 102,
Greenleaf & Co., rectifiers and wholesale liquor-dealers,
10 and 12 South St.,
Philadelphia, Pa.
Stamp No. 64,275.

To which the rectifier may add any known trade-mark adopted and used by him; or, where such trade-mark is the distinctive name of the spirits as known to the trade, it may be used as the name of the spirits.

This brand or mark will be understood to represent that the package is a rectifier's original package, and that the spirits contained therein were rectified, refined, purified, redistilled, or compounded, and put up by the party named as a rectifier, and at the place stated in such brand or mark.

When the contents of a cask of rectified spirits are drawn from the original cask or package and placed in another cask or package containing not less than ten gallons, they must be again gauged and inspected, the number of wine and proof gallons cut upon the bung-stave, and upon the head of each cask must be marked or branded the name of the gauger, the time and place of inspection, the proof of the spirits, the particular name of the spirits as known to the trade, the name and place of business of the rectifier, with the date of the original inspection and the serial number of the stamp for rectified spirits upon the original package. This mark or brand will be substantially as follows:—

Amos F. Wright,
U. S. Gauger 2d Dist. Ohio.
Insp. May 20, 1869.
For Smith & Co., wholesale liquor-dealers,
Cincinnati, O.
Rye whiskey, proof 102.
Redistilled by
Greenleaf & Co., rectifiers & wholesale liquor-dealers,
10 & 12 South St., Philad'a, Pa.
Orig. Insp. May 15, 1869. Stamp No. 64,275.

3. *Wholesale Liquor-Dealers.*

Where wholesale liquor-dealers purchase spirits, regularly stamped and bearing the marks and brands required by these regulations, and sell the same without change, no additional inspection or marking is required. Where, however, they draw from such stamped and branded packages, and fill other packages for shipment, sale, or delivery, the spirits must be again gauged and inspected and the wholesale liquor-dealer's stamp attached, and such packages must be marked with the name of the dealer and the particular name of the spirits as known to the trade. Where the package so filled contains ten gallons or more, it must also be branded or marked as required by section forty-seven, substantially as hereinbefore provided in other cases of change of package.

4. *Retail Liquor-Dealers.*

Retail liquor-dealers are only authorized to sell in quantities less than five gallons, and no reinspection or stamping of the packages of spirits so sold by them is required.

The spirits which they purchase must be in packages properly stamped, marked, or branded, and remain in the original casks or packages until drawn off for sale in retail packages, except where it becomes necessary from leakage or other cause to change the package. Where such change is made, such spirits must be again inspected and gauged, and the new package branded in accordance with the provisions of section forty-seven.

All spirits held by any wholesale or retail liquor-dealer will be held and taken to be "intended for sale."

In all cases where spirits are inspected and gauged, the number of wine and proof gallons must be cut upon the bung-stave.

5. *Forfeited Spirits sold by United States Marshals.*

Under the provisions of section fifty-eight, of the act of July 20, 1868, all distilled spirits forfeited to the United States, sold by order of court, whether condemned before or after the passage of the act, are to be sold subject to tax, and the purchaser must immediately and before he takes possession of such spirits pay the tax thereon. And if any tax-paid stamps are affixed to any cask or package so condemned, such stamps must be obliterated and destroyed by the collector or marshal after forfeiture and before such sale.

The spirits so sold are subject to this tax without regard to the question whether or not any tax has been previously paid

thereon. The tax to be paid is fifty cents per wine gallon when below proof, and per proof gallon when above proof; fractions of a gallon to be taxed as a gallon. This is substantially a new tax, accruing upon the sale of such spirits by the marshal, and is to be paid in the district where the sale is made, and it is to be collected upon the quantity sold by the marshal.

When, therefore, a sale is made by the marshal, he will require the purchaser, before receiving possession of the spirits, to deliver to him the receipt of the collector of the district in which the sale is made for the tax due upon the same, which receipt will be executed on Form 105. The purchaser, in order to obtain the receipt, will deliver to the collector a statement to be signed by the United States marshal, giving the number of packages, the number of wine and proof gallons in each, with the date of the sale and the name of the purchaser, and the collector will issue for every such cask or package a tax-paid stamp, and cause the same to be affixed thereto. Upon the face of the receipt, Form 105, the collector will indorse the words, "Tax-paid stamps issued," and upon the stamps, "Tax on spirits sold by United States marshal," with the date of the sale.

Before the delivery of any spirits so sold to the purchaser, the marshal will mark with a stencil-plate, or brand with a branding-iron, each cask or package with his name and official title, together with the date and place of sale, and the words tax paid, and the number of proof gallons, with the name of the gauger who gauged the same, and the date of gauging.

No stamp, brand, or mark which may be upon the barrels at the time the spirits are condemned, is to be removed or obliterated, except the tax-paid stamp, and the new tax-paid stamp and mark of the marshal should be so placed as not to cover or deface any of such stamps, marks, or brands.

Collectors will furnish distillers, rectifiers, and wholesale liquor-dealers with a copy of these regulations, and all officers of internal revenue will see that the regulations are promptly and strictly carried out; and any neglect or failure to comply with the same, on the part of any officer, will be deemed sufficient cause for his immediate dismissal from office.

C. DELANO, *Commissioner.*

Approved:

WILLIAM A. RICHARDSON,

Acting Secretary of the Treasury.

REPORT OF THE COMMITTEE ON METHODS OF INSPECTING AND ASSESSING TAX ON DISTILLED SPIRITS.

TREASURY DEPARTMENT,
February 15, 1866.

SIR: I have the honor to request that a committee of the National Academy of Sciences be appointed to report to this department on the best method of proving and gauging alcoholic liquors, with a view to the establishment of such rules and regulations as may be necessary to insure a uniform system of inspection of spirits subject to duties.

Very respectfully,
H. McCULLOCH,
Secretary of the Treasury.

Professor JOSEPH HENRY,
Vice-President of the National Academy of Sciences.

REPORT OF THE NATIONAL ACADEMY OF SCIENCES TO THE SECRETARY OF THE TREASURY ON THE BEST METHOD OF PROVING AND GAUGING DISTILLED SPIRITS.

The subjects of inquiry presented to this committee are twofold. The first branch, relating to the best mode of proving and gauging distilled spirits subject to duty, has been fully considered; conclusions have been reached and adopted by the department. The second branch, relating to the means of preventing fraud in collecting the revenue on distilled spirits, is still under consideration, as the most promising inventions have only been submitted at a recent date. The present report will, therefore, only cover the first branch of the subject; the remainder being reserved for a future report. In considering the subject of hydrometers the committee have, in the first instance, reviewed the existing regulations and practice; next have sought to discover the grounds of their insufficiency under the new circumstances arising from the high tax upon distilled spirits; and finally have endeavored to devise means to meet the exigencies of the case.

Previous to the imposition of the internal revenue tax imported spirits only were subject to duty. The instruments used

in ascertaining their value were adopted upon the recommendation of Professor A. D. Bache, accompanying a report of investigations made under his direction by Professor R. S. McCulloh on the subject of alcoholometers. This report, dated May 26, 1848, contains an exhaustive review of the scientific investigations and practical methods in all countries up to that time. It was printed as a public document (30th Congress, 1st session, Senate Ex. Doc. No. 50), and, together with the tables printed in a subsequent document (31st Congress, 2d session, Senate Ex. Doc. No. 28), forms a most valuable manual of reference for the subject under consideration. The recommendations made by Professor Bache were as follows:—

1. That the strength of liquors should not be referred to the arbitrary degrees of an artificial system, as those of Dycas's hydrometer, but be expressed in per centums of alcohol contained by volume.

2. That no reference be made in terms of "proof," as "first proof," "second proof," &c., which are from legal enactment, and not commercial use, in ascertaining or describing the strengths of alcoholic liquors; but that such description be made in per centum by volume of contained alcohol.

3. That all gaugings or measurements of alcoholic liquids be referred to the standard temperature of 60° of Fahrenheit's thermometer.

4. That in stating the per centum by volume of pure alcohol contained in a liquid, it be reduced to its equivalent at the same standard temperature of 60° Fahrenheit.

5. That the centesimal hydrometer be adopted in determining the strength of liquids; and provisionally, until a better instrument is furnished, the centesimal alcoholometer of Tralles be used, with a suitable manual of tables to accompany the instrument.

The experience of the past fifteen years has fully proved the wisdom of the system then adopted, which has been found well adapted to the purposes for which it was intended.

The Tralles hydrometer was not used only by the government inspectors, but gradually found its way into use among importers of liquors, and in first-class distilleries. When, however, it became necessary to inspect and ascertain the strength of all the spirits distilled in the country, under a system of very high taxation, various objections were raised to its use. The principal ones are the following:—

(1.) The non-conformity of its scale with the custom of the trade. The Tralles instrument shows the per cents. of *alcohol* in the given sample of spirits, while all liquors are bought and sold by their percentage of *proof spirits;* and although the former are readily converted into the latter, when their relation is fixed, and especially when that relation is so simple as to define proof spirit to contain one-half its volume of alcohol, yet it was claimed to be desirable that the inspector's brand should correspond to the commercial designation of the article. Moreover, the duty being laid on proof spirit, an instrument show-

ing per cents. of that liquor would lessen the labors of the inspector.

(2.) The high rate of duty, amounting to six or eight times the value of the raw spirits, required that their value should be ascertained to within one per cent. In order to give single per cents. on proof spirit, it would be necessary to observe and take into account half per cents. of the Tralles instrument. This would require closer observation than there is usually time and opportunity for, while the use of fractions would materially increase the work of computation.

(3.) The circumstances under which the inspection of large lots of liquor has to be performed, on the occasion of their shipment or delivery for storage at the government warehouses, are such as to render quite impracticable the use of instruments requiring great care in handling, and a certain degree of leisure in observation. It is often necessary to perform the inspection in the open air, exposed to inclement weather, and the greatest practicable despatch is generally requisite. Under such conditions, the length of the Tralles instrument, the care required in reading it to half degrees under the surface of the liquid, and the effect of the wind upon the exposed part of the stem, were found to be very objectionable. The further lengthening of the stem with the view of expanding the scale would, for these reasons, be quite out of the question.

(4.) It was found that the "Manual for Inspectors of Spirits" [McCulloh's] gives, for temperatures varying considerably from 60° *Fahr.*, sensibly erroneous values for the true equivalents to the indications of the hydrometer. There is, in fact, a systematic error in those tables, the origin of which the committee have been unable to trace. Professor McCulloh, in the second report, above referred to, gives in full the data from which the tables in the Manual are derived, and states with great precision the processes of computation, which are perfectly correct. But the figures in the Manual do not correspond to those data and processes, and their error is attested by direct experiment. Thus, according to the fundamental data, an indication by the hydrometer of 50 per cent. at a temperature of 30° *Fahr.* corresponds to 55.94 *true per cent.*, while the Manual gives 57.22; and for the same indication at 100° *Fahr.* the true equivalent is 41.33, while the Manual gives 42.96.

The foregoing considerations led the committee to admit the necessity of adopting a more convenient instrument and providing correcter tables.

With a view to ascertaining the wants of the public in this matter, the opinions of several experienced inspectors were heard, among whose number the committee are specially in-

debted to Inspector G. W. Guysé for clear and practical information. One of the committee also conferred with leading distillers and rectifiers of spirits, as well as with revenue officers in different cities.

The general opinion was found to be in favor of adapting the scale of the new hydromer to the custom of the trade, according to which the strength of spirits is reckoned *above* and *below proof*, in degrees intended to represent per cents. A few persons who had become used to the Tralles hydrometer, and learned the convenience of not having to deal with negative quantities, gave the preference to that instrument.

Upon general considerations it would seem desirable that one instrument should be used for the ascertainment of specific gravities of all liquids, *such as spirits*, *acids*, *oils*, *&c.*, the corresponding values of which would be inferred by reference to tables. It is apparent, however, that such an instrument would not be as convenient for the several trades, who each deal with one class of liquid only, as separate instruments for the use of each, giving as direct an indication of the value as practicable. Admitting that the government inspection should conform to the customs of trade, so far as consistent with correct scientific principles, the idea of introducing a universal *aerometer*, or specific gravity instrument, must be dismissed, although it is doubtless admirably adapted for a laboratory.

Having determined to adhere to the use of some instrument expressly adapted to alcoholic spirits, the first question to be decided was whether *alcohol* or *proof spirit* should be the standard of reference. It certainly appears more natural to estimate the value of a liquid by the quantity of that element contained in it which constitutes its valuable property. But when, as in this case, the price is habitually referred to a certain mixture of the elements which is the most common form of the product, while the valuable element is attainable in purity only by elaborate and expensive chemical processes, the committee see no difficulty in yielding to the general custom and adopting proof spirit as the standard. There is no sacrifice of scientific precision when the relation of this standard to standard alcohol is positively defined. The cases in which it becomes desirable to convert the per cents. of proof spirit into per cents. of alcohol are very few in number compared with those in which the reverse process would be necessary, if in the inspection of spirits alcohol were referred to as the standard, since, in fact, such would be the case with the branding of every barrel.

Proof spirit has been heretofore defined by law to be alcoholic liquor, containing 50 per cent. by volume of alcohol, according to the Tralles hydrometer. The committee have seen

no reason to make a change in the specific gravity of the alcohol to be considered as standard, but have followed Bache and McCulloh in adopting Tralles' specific gravity of .7939 at 60° Fahrenheit. More recent experiments have indeed rendered it quite probable that *absolute* alcohol is yet sensibly lighter; but since that point remains still unsettled, and the possible difference is far within the limits of practical testing, and since prices have long adapted themselves to the Tralles standard of strength, any change has appeared inexpedient.

In order, however, to free the definition of proof spirit from reference to a particular instrument, the committee, under date of April 19, 1866, recommended to the department the following provision of law, which was embodied in the tax law, providing at the same time for the adoption of other results of their inquiries, viz:—

> That proof spirit shall be held and taken to be that alcoholic liquor which contains one-half its volume of alcohol of a specific gravity of .7939 at 60° Fahrenheit, and the duties on all spirits shall be levied according to their equivalent in proof spirit; and the Secretary of the Treasury is hereby authorized to adopt, procure, and prescribe for use such hydrometers, weighing and gauging instruments, meters, or other means for ascertaining the strength and quantity of spirits subject to tax, and to prescribe such rules and regulations as he may deem necessary to insure a uniform and correct system of inspection, weighing, and gauging of spirits subject to tax, throughout the United States.

The specific gravity of proof-spirit thus defined, has been found by the experiments of Gilpin and Blagden to be .93353 at 60° Fahrenheit; water at its maximum density being taken as unity.

FORM OF HYDROMETERS.

The standard of proof being thus fixed, it was next decided that the hydrometer scale should be so marked and numbered as to show at the temperature of 60° Fahrenheit the equivalent of proof spirit contained in the sample tested, indicated in per cents. by volume. Thus, proof spirit would be indicated by 100; 40 per cent. over proof, by 140; standard alcohol, by 200; 20 per cent. below proof, by 80. This was deemed preferable to the employment of the negative scale under-proof, because it would simplify calculations and remove a fruitful source of mistakes in the application of the subtractive temperature corrections to negative quantities. The practical gaugers consulted readily assented to this proposition. As it was desired that the scale of the instruments should be so open as to indicate the nearest whole per cent. so decidedly that two different observers working hastily might not differ in their readings by so much as one per cent., it was agreed that the

average length of a scale division should be about one-tenth of an inch for the range between 80 and 180 per cent., those being the strengths which occur in practice. It appeared, moreover, advisable, from considerations of practical conveniences, that the cup for containing the sample should not exceed seven or eight inches in height. Hence it was determined that a series of hydrometers should be provided, embracing together the entire scale, and so adapted to the ordinary classes of spirits that in proving a particular lot of barrels the inspector would require to use only one of the instruments. The scale was divided therefore as follows:—

1. From 80 per cent. to 120 per cent. for proof spirits and whiskeys.
2. From 100 per cent. to 140 per cent. for ordinary high wines.
3. From 130 per cent. to 170 per cent. for extra high wines.
4. From 160 per cent. to 200 per cent. for alcohols.

To these was added a fifth instrument giving the per cents. from 0 to 100, or from water to proof spirit, for the sake of completeness, and for occasional use with low wines.

The set of hydrometers adopted are figured on Plate XI.

A great variety of the hydrometers in common use were examined by the committee, most of these being of silver or brass, with spheroidal bulbs, and two or more scales on the stem, with corresponding weights to be attached to the bulb when used in denser spirits. Such forms of construction were deemed to be objectionable for standard instruments, on account of their liability to become erroneous, by accident or designs by indentation of the bulb or alteration of the weights. A hydrometer of glass, sufficiently strong to bear ordinary handling, but which will break by a blow or fall, that would change the form of one of metal, was deemed far safer.

The committee next considered the question whether the thermometer should be blown into the bulb, as in Greiner's alcoholometer, or whether it should be attached to the can or cup in which the liquor is tested, as commonly used. The latter form was deemed preferable, as the former would greatly increase the cost and fragility of the hydrometers.

The glass vessel for holding the spirit, as used with Greiner's instrument, affords the means of reading the scale very accurately by looking at it through the glass below the meniscus formed by capillary attraction. It may be well doubted, however, whether under the ordinary circumstances of practice the inspectors would use the care and deliberation requisite in making the observation in that form. Besides, the fragility of

the glass vessel forms a serious objection to its use. The committee have therefore given the preference to the ordinary copper can, eight inches in height, two inches in diameter, with a thermometer so attached as to have the bulb in contact with the liquid, and to be protected from injury by projecting rims of metal. This can should always be quite full when the hydrometer is immersed in the liquid, so that the reading can be taken with the eye nearly in the surface-plane of the liquid.

For the loading of the bulb, a method proposed by Mr. G. Tagliabue, of New York, was approved by the committee. It consists of the requisite weight of fusible metal placed in the bottom of the bulb, and fused there into a closely fitting button. This is very compact and strong, and avoids the narrow neck of the bulb filled with mercury or shot, common in other forms of glass hydrometers.

The form of hydrometers being thus determined upon, the next step was to establish the scales for the same. The following table gives the densities of alcoholic spirits for every per cent. of alcohol contained in the mixture, by volume, reckoned upon the volume of the mixture of alcohol and water. This table is derived from the experiments of Gilpin and Blagden, and is more generally known as Tralles' alcohol scale. The densities are referred to water at its maximum density—about 39.4° Fahrenheit—as unity; hence that of 0 per cent., or water, is given as .99910, that being its density at 60° Fahrenheit, the standard temperature of the table. The length of the part of the stem immersed is likewise given, being counted from the point at which the hydrometer floats in water of maximum density. The figures are derived as follows:—

Since the product of the volume immersed into the density of the liquid is always constant, the immersed volume is inversely proportional to the density. The numbers in the table, therefore, are the reciprocals of the densities diminished by unity, which is assumed to be the volume immersed in water.

Specific gravity of alcoholic spirits at 60° *Fahrenheit, that of water at its greatest density being* 1.00000, *and corresponding hydrometer scale.*

Per cent. of alcohol.	Specific gravity at 60°.	Length of immersed part of the stem.	Per cent. of alcohol.	Specific gravity at 60°.	Length of immersed part of the stem.	Per cent. of alcohol.	Specific gravity at 60°.	Length of immersed part of the stem.
0	.99910	9	34	.95963	420	68	.89415	1184
1	.99768	24	35	.95829	435	69	.89174	1214
2	.99626	38	36	.95693	450	70	.88923	1246
3	.99484	52	37	.95549	465	71	.88673	1278
4	.99342	66	38	.95406	481	72	.88420	1310
5	.99200	81	39	.95256	498	73	.88168	1342
6	.99071	94	40	.95106	515	74	.87911	1375
7	.98947	107	41	.94946	532	75	.87651	1409
8	.98822	119	42	.94784	550	76	.87388	1443
9	.98698	133	43	.94616	569	77	.87122	1478
10	.98574	145	44	.94447	588	78	.86855	1514
11	.98463	156	45	.94274	608	79	.86581	1550
12	.98353	168	46	.94098	628	80	.86306	1587
13	.98242	179	47	.93918	648	81	.86027	1624
14	.98132	191	48	.93731	669	82	.85743	1662
15	.98026	202	49	.93543	690	83	.85458	1701
16	.97923	212	50	.93353	712	84	.85168	1741
17	.97819	224	51	.93161	734	85	.84874	1782
18	.97716	234	52	.92959	758	86	.84580	1823
19	.97614	245	53	.92756	781	87	.84271	1867
20	.97512	255	54	.92552	805	88	.83955	1910
21	.97410	266	55	.92344	829	89	.83640	1956
22	.97308	277	56	.92134	854	90	.83310	2003
23	.97205	288	57	.91921	879	91	.82971	2052
24	.97103	299	58	.91705	905	92	.82632	2102
25	.97000	309	59	.91487	931	93	.81274	2155
26	.96894	321	60	.91264	957	94	.81907	2209
27	.96787	332	61	.91040	984	95	.81525	2266
28	.96680	343	62	.90815	1011	96	.81117	2327
29	.96568	355	63	.90589	1039	97	.80703	2391
30	.96454	368	64	.90360	1067	98	.80284	2456
31	.96339	380	65	.90130	1095	99	.79846	2524
32	.96215	393	66	.89894	1125	100	.79390	2596
33	.96092	407	67	.89656	1154			

The scale given in the preceding table holds good, proportionally, for whatever length of scale be employed, and for all parts of scales. To find, therefore, the graduation of the stem for the hydromèter, indicating from 50 to 70 per cent. alcohol, or from 100 to 140 per cent. proof spirit, we take the difference between 712 and 1246, the corresponding parts in the table, giving 534 parts to divide on the scale, in the proportion indicated by the table. If the whole length of this scale is to be 5.34 inches, every part will be represented by one-hundredth of an inch.

In the manufacture of glass hydrometers, it is not practicable to obtain the scale of a given length; the graduation, therefore, is usually made by hand. In order to avoid this laborious and inaccurate process, a series of fifteen scales were engraved and printed for each one of the five instruments, ranging from 4 inches to 4.7 inches in length, within which limits it was found easy to keep the variation. After "pointing" each stem, or marking on it the extreme readings, by comparison with a standard instrument floating in the same liquid, that scale was selected which, among the fifteen, most nearly had the required length. In this manner no error greater that one-quarter of one per cent. could be introduced, which is quite inappreciable in practicc.

In order to find the diameter of the stem which will give a certain length of scale between given per cents., we may proceed as follows: Let g and g' represent the specific gravities of the given per cents., V and V' the immersed volumes of the hydrometer; since in each case the weight of the displaced liquid is equal to the weight of the hydrometer, we always have $Vg = V'g'$. Thus, for a hydrometer indicating from proof to 140 per cent., we have, from the preceding table—

Specific gravity of proof spirit, $.93353 = g$.
Specific gravity of 140 per cent., $.88923 = g'$.

If we assume the immersed volume to be 2.65 cubic inches for proof, then we find $V' = 2.782$; hence, the volume of the stem immersed in g' is 2.782—2.65 cubic inches; and if we make the length of the stem immersed between g and g' 4 inches, its diameter will be found .20 inch, nearly.

It is convenient to state, in this connection, the measures taken for securing accuracy in the manufacture of the hydrometers ordered by the Treasury Department upon the recommendation of the committee, and for their verification before acceptance by the department.

Dr. John Torrey and Dr. F. A. P. Barnard, members resident in New York, prepared, with great precision, standard mixtures of the specific gravities corresponding to the extreme and middle points of the proposed scales, and by immersion in those mixtures marked a series of very delicate floats, having large bulbs and thin stems, one for each mixture. These floats were used by Mr. Tagliabue to point the hydrometers he manufactured for the department.

Similar mixtures were prepared in Washington, by Dr. B. F. Craig, for the Office of Weights and Measures, when, under the direction of Mr. Hilgard, the hydrometers were tested for the department. It will be understood that such mixtures would

not long maintain their strength after exposure to the air, and that they were only used for the selection of some sets of standard hydrometers, with which others were afterwards compared in mixtures of convenient strength.

It is gratifying to state that of several thousand instruments inspected, only very few were found to be in error over one-half per cent., and those mostly by several degrees, owing to some slipping of the scale or other accident.

MANUAL OF TABLES FOR TEMPERATURE CORRECTION.

In the preparation of the manual of tables which accompanies the hydrometers, the experiments made by Gilpin and Blagdon for the British government formed the principal basis of the work, as they are that of the tables of Tralles, and of Bache, and McCulloh, previously quoted.

The computations made by McCulloh have been verified throughout, and have received some corrections, especially in the interpolated parts between 93 and 100 per cent.

The extension of the tables from 30° to 20° temperature was rejected because it was thought necessary to give the corrections for temperatures as low as zero of Fahrenheit's scale, which would render additional experimental data indispensable, as Gilpin's experiments were not extended below 30°. The committee was informed by inspectors that it frequently happened that spirits arriving during winter in Chicago or Buffalo, and requiring to be inspected in bond, were found to be of a temperature approaching zero.

With a view to obtaining the requisite experimental data, the Treasury Department, at the suggestion of your committee, requested the Surgeon-General of the United States to cause such observations to be made at his laboratory in Washington City, where special facilities for the purpose were understood to exist. Before these experiments could be made, the committee became acquainted with the labors of Dr. Recknagel, expressly undertaken with a view to supply the want in alcoholometry above stated, and published in the proceedings of the Munich Academy of Science, for 1866. The results of Dr. Recknagel are fully confirmed by those subsequently obtained by Dr. Craig in the laboratory of the Surgeon-General's office.

The appended tables are the following:—

Table I. gives the densities found by Gilpin and Blagden for spirits of different strengths, at temperatures varying from 30° to 80° Fahrenheit. The spirit used in these experiments has a density of 0.825 at 60° Fahrenheit; referred to water at that temperature as unity. It corresponds to 92.6 per cent. of the

standard adopted by Tralles. The table also gives the corresponding per cents. by volume according to Bache and McCulloh.

Table II. gives Gilpin and Blagden's densities, corrected per errors of observation by the methods of curves and least squares, according to Bache and McCulloh, and reduced to the standard of Tralles.

Table III., derived from the preceding, shows the true densities and volumes of alcohol of every strength from 1 to 100 per cent., and for every five degrees of temperature from 30° to 100°. The portion of this table above temperature 80° is derived from the other part by interpolation with second differences, as fully stated by McCulloh *l. c.*, and the extension of the densities from 93 to 100 per cent. is derived from a comparison of the observations by Gay Lussac, Delegennes, Tralles, Muncke, and McCulloh. The supplement to Table III..gives the specific gravities of spirits between temperatures 0° and 25° Fahrenheit, from the observations by Dr. Recknagel, reduced to the standard of Tralles.

Table IV., derived from the preceding one, shows the apparent densities, for glass vessels or hydrometers, and the apparent per cents., for every true per cent. and for every fifth degree of temperature from 30° to 100°. By *apparent per cents.* is meant the per cents. indicated by a glass hydrometer, which is graduated to show true per cents. when the spirit is at a temperature of 60° Fahrenheit. These indicated or apparent per cents. are obtained from a table of densities at 60°, interpolated for tenths of a per cent., the apparent specific gravities for each true per cent. being used as arguments. The supplement to Table IV. finally contains the same data for temperatures between 0° and 25°, and for spirits between 30 and 100 per cent., from Recknagel's experiments.

This table furnishes us with the data required for practical use in alcoholometry, viz., a comparison between the true and indicated per cents. The argument, however, is the true per cent., which appears in integer numbers, while the corresponding indicated per cents. are fractional. We require, on the contrary, for the Manual, a table in which the indicated per cents. are the integer argument, as observed on the hydrometer.

The surest mode of effecting the required interpolation, and best calculated to provide a check against all preceding errors, was deemed to be the graphic method, on a sufficiently large scale to make hundredths of one per cent. sensible and tenths certain.

Plate XII. shows the scheme of projected sheets on one-tenth their actual scale, and exhibits at the same time the general law. Plate XIII. gives one of the sheets on the full scale

and is intended to illustrate the process. It is by this means that Table I. of the Manual has been constructed. Tables II. and III. of the same are based upon the same experimental data as heretofore detailed. The computations and graphic operations have been mainly performed by Mr. F. Hudson; those for temperatures below 30° by Mr. F. H. Agnew; both of whom are entitled to great praise for the accuracy of their work.

The following table, computed by Mr. Hudson, will be found of value, giving the relations between the per cents. by weight and by volume, and the actual quantities of water and alcohol contained in determinate mixtures by weight. It will be borne in mind that when alcohol and water are mixed a contraction takes place, varying with different proportions. Thus it requires 50 volumes of alcohol and 53.67 volumes of water to produce 100 volumes of proof spirit. The weight of 100 gallons of water at 60° Fahrenheit is taken at 833.14 pounds avoirdupois.

Table of percentage by weight and volume, and of weights of alcohol and water in 100 gallons of spirits at 60° Fahrenheit.

Per cent.			Specific gravity of spirit. (Water at 60° = 1.)	Weight of alcohol in 100 gallons spirit.	Weight of water in 100 gallons spirit.	Weight of 100 gallons of spirit.
Alcohol.		Water by volume.				
By weight.	By volume.					
				Pounds.	*Pounds.*	*Pounds.*
5	6.24	94.17	0.99131	41.29	784.61	825.90
10	12.38	88.56	.98398	81.98	737.81	819.79
15	18.45	83.09	.97758	122.17	692.29	814.46
20	24.45	77.72	.97144	161.85	647.50	809.35
25	30.36	72.38	.96500	200.99	602.99	803.98
30	36.15	67.03	0.95757	239.34	558.45	797.79
35	41.80	61.69	.94901	276.73	513.93	790.66
40	47.29	56.37	.93948	313.08	469.63	782.72
45	52.62	51.10	.92916	348.35	425.77	774.12
50	57.78	45.92	.91833	382.55	382.55	765.10
55	62.79	40.82	0.90718	415.69	340.12	755.81
60	67.64	35.83	.89582	447.80	298.54	746.34
65	72.33	30.95	.88416	478.81	257.82	736.63
70	76.85	26.17	.87240	508.78	218.06	726.83
75	81.21	21.50	.86044	537.70	179.16	716.87
80	85.41	16.97	0.84831	565.40	141.36	706.76
85	89.41	12.54	.83581	591.89	104.46	696.35
90	93.19	8.23	.82278	616.94	68.55	685.49
95	96.71	4.05	.80895	640.26	33.71	673.97
100	100.00	0.00	.79461	662.02	0.00	662.02

The Manual gives the equivalents of true per cent. for indications of the hydrometer and thermometer. This is deemed to be the best form in which the corrections for temperature can be put for practice, since it saves all arithmetical operations, especially those that would ordinarily be performed mentally, without check and liable to error. For the advantage of those persons, however, who perform such operations with facility, and who would be likely to use from memory a table of the corrections most frequently occurring in practice, a graphic table of corrections is given in Plate XIV., which is so perspicuous as to require no special explanation. The experiments made by Dr. Craig in the laboratory of the Surgeon-General's Office follow Table IV., preceded by an explanation of the method employed.

The report to the Treasury Department and the tables of the Manual for inspectors of spirits follow next, and complete this portion of the report of the committee to the academy.

TABLE I.—*Containing the densities found by Messrs. Gilpin and Blagden for spirits of different strengths, and at various temperatures; extracted from the 84th volume of Philosophical Transactians*, 1794.

Temperature 30°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100.00	.83896	100+100	56.15	.94222
5	96.49	.84995	95	54.84	.94447
10	93.14	.85957	90	53.45	.94675
15	89.99	.86825	85	51.98	.94920
20	87.00	.87585	80	50.42	.95173
25	84.18	.88282	75	48.75	.95429
30	81.53	.88921	70	46.96	.95681
35	79.03	.89511	65	45.05	.95944
40	76.67	.90054	60	43.00	.96209
45	74.44	.90558	55	40.80	.96470
50	72.33	.91023	50	38.43	.96719
55	70.33	.91449	45	35.87	.96967
60	68.42	.91847	40	33.10	.97200
65	66.62	.92217	35	30.11	.97418
70	64.90	.92563	30	26.80	.97635
75	63.27	.92889	25	23.33	.97860
80	61.71	.93191	20	19.49	.98108
85	60.22	.93474	15	15.30	.98412
90	58.81	.93741	10	10.71	.98804
95	57.45	.93991	5	5.04	.99334

Temperature 35°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100.00	.83672	100+100	56.18	.94025
5	96.49	.84769	95	54.87	.94249
10	93.14	.85729	90	53.49	.94484
15	89.99	.86587	85	52 02	.94734
20	87.00	.87357	80	50.46	.94988
25	84.19	.88059	75	48.79	.95246
30	81.54	.88701	70	47.00	.95502
35	79.05	.89294	65	45.09	.95772
40	76.69	.89839	60	43.05	.96048
45	74.47	.90345	55	40.85	.96315
50	72.35	.90811	50	38.47	.96579
55	70 35	.91241	45	35.92	.96840
60	68.45	.91640	40	33.15	.97086
65	66.65	.92009	35	30.15	.97319
70	64.93	.92355	30	26.91	.97556
75	63.30	.92680	25	23.38	.97801
80	61.74	.92986	20	19.54	.98076
85	60.26	.93274	15	15.34	.98397
90	58.84	.93541	10	10.73	.98804
95	57.48	.93790	5	5.65	.99344

Temperature 40°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100.00	.83445	100+100	56.22	.93827
5	96.49	.84539	95	54.91	.94058
10	93.16	.85507	90	53.53	.94295
15	90.00	.86361	85	52.06	.94547
20	87.02	.87134	80	50.49	.94802
25	84.21	.87838	75	48.82	.95060
30	81.57	.88481	70	47.04	.95328
35	79.07	.89073	65	45.14	.95602
40	76.71	.89617	60	43.09	.95879
45	74.49	.90127	55	40.89	.96159
50	72.38	.90596	50	38.52	.96434
55	70.38	.91026	45	35.96	.96706
60	68.48	.91428	40	33.20	.96967
65	66.67	.91799	35	30.21	.97220
70	64.96	.92151	30	26.96	.97472
75	63.33	.92476	25	23.42	.97737
80	61.77	.92783	20	19.58	.98033
85	60.29	.93072	15	15.38	.98373
90	58.87	.93341	10	10.76	.98795
95	57.52	.93592	5	5.67	.99345

Temperature 45°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100.00	.83214	100+100	56.25	.93621
5	96.49	.84310	95	54.95	.93860
10	93.16	.85277	90	53.56	.94096
15	90.01	.86131	85	52.09	.94348
20	87.03	.86905	80	50.53	.94605
25	84.23	.87613	75	48.86	.94871
30	81.58	.88255	70	47.08	.95143
35	79.09	.88849	65	45.17	.95423
40	76.73	.89396	60	43.13	.95705
45	74.51	.89909	55	40.93	.95993
50	72.41	.90380	50	38.57	.96280
55	70.41	.90812	45	36.01	.96563
60	68.51	.91211	40	33.25	.96840
65	66.70	.91584	35	30.26	.97110
70	64.99	.91937	30	27.01	.97384
75	63.36	.92264	25	23.47	.97666
80	61.80	.92570	20	19.62	.97980
85	60.32	.92859	15	15.41	.98338
90	58.90	.93131	10	10.79	.98774
95	57.55	.93382	5	5.69	.99338

TABLE I.—Continued.

Temperature 50°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100 + 0	100.00	.82977	100+100	56.29	.93419
+ 5	96.50	.84706	95	54.99	.93658
+10	93.17	.85042	90	53.60	.93897
+15	90.02	.85902	85	52.13	.94149
+20	87.05	.86676	80	50.57	.94414
+25	84.25	.87384	75	48.90	.94683
+30	81.61	.88030	70	47.12	.94958
35	79.12	.88626	65	45.22	.95243
40	76.76	.89174	60	43.18	.95534
45	74.54	.89684	55	40.98	.95831
50	72 44	.90160	50	38.61	.96126
55	70.44	.90596	45	36 06	.96420
60	68.54	.90997	40	33.30	.96708
65	66.74	.91370	35	30.31	.96995
70	65.02	.91723	30	27.06	.97284
75	63.39	.92051	25	23.52	.97589
80	61.84	.92358	20	19.67	.97920
85	60.85	.92647	15	15.45	.98293
90	58.94	.92919	10	10.82	.98745
95	57.59	.93177	5	5.70	.99316

Temperature 55°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100 00	.82736	100+100	56.33	.93208
5	96.50	.83834	95	55.03	.93452
10	93.18	.84802	90	53.64	.93696
15	90.03	.85664	85	52.17	.93948
20	87.06	.86441	80	50.61	.94213
25	84.27	.87150	75	48.94	.94486
30	81.63	.87796	70	47.16	.94767
35	79.14	.88393	65	45.26	.95057
40	76.79	.88945	60	43.22	.95357
45	74 57	.89458	55	41.03	.95662
50	72.47	.89933	50	38.66	.95966
55	70.47	.90367	45	36.11	.96272
60	68.57	.90768	40	33.35	.96575
65	66.77	.91144	35	30.36	.96877
70	65 06	.91502	30	27.11	.97181
75	63.43	.91837	25	23.57	.97500
80	61.87	.92145	20	19.71	.97847
85	60.39	.92436	15	15.49	.98239
90	58.97	.92707	10	10.85	.98702
95	57.62	.92963	5	5.71	.99284

Temperature 60°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100 + 0	100.00	.82500	100+100	56.36	.93002
+ 5	96.51	.83599	95	55.06	.93247
+10	93 19	.84568	90	53.68	.93493
15	90.04	.85430	85	52 21	.93749
20	87.08	.86208	80	50.65	.94018
25	84.28	.86918	75	48 98	.94296
30	81.65	.87569	70	47.20	.94579
35	79.16	.88169	65	45.30	.94876
40	76.81	.88720	60	43.26	.95181
45	74.59	.89232	55	41.07	.95493
50	72.49	.89707	50	38.71	.95804
55	70.49	.90144	45	36.16	.96122
60	68.60	.90549	40	33.40	.96437
65	66.80	.90927	35	30.40	.96752
70	65.09	.91287	30	27.16	.97074
75	63.46	.91622	25	23.61	.97410
80	61.91	.91933	20	19.75	.97771
85	60.43	.92225	15	15.52	.98176
90	59.01	.92499	10	10.87	.98654
95	57.66	.92758	5	5.73	.99244

Temperature 65°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100 00	.82262	100+100	56.40	.92794
5	96.51	.83362	95	55.10	.93040
10	93.20	.84334	90	53.72	.93285
15	90.05	.85193	85	52.25	.93546
20	87.09	.85976	80	50.69	.93822
25	84.30	.86686	75	49.02	.94099
30	81.67	.87337	70	47.25	.94388
35	79.18	.87938	65	45.35	.94689
40	76.84	.88490	60	43.31	.95000
45	74.62	.89006	55	41.11	.95318
50	72.52	.89479	50	38.75	.95635
55	70.52	.89920	45	36 20	.95962
60	68.63	.90328	40	33.44	.96288
65	66.83	.90707	35	30.45	.96620
70	65.12	.91066	30	27.20	.96959
75	63.49	.91400	25	23.66	.97309
80	61.94	.91715	20	19.79	.97688
85	60.46	.92010	15	15.56	.98100
90	59.04	.92283	10	10.89	.98594
95	57.69	.92546	5	5.74	.99194

Temperature 70°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100 + 0	100.00	.82023	100+100	56.44	.92580
5	96.52	.83124	95	55.14	.92828
10	93.20	.84092	90	53.75	.93076
15	90.06	.84951	85	52.28	.93337
20	87.11	.85736	80	50.73	.93616
25	84.32	.86451	75	49.06	.93898
30	81.69	.87105	70	47.29	.94193
35	79.20	.87705	65	45.39	.94500
40	76.86	.88254	60	43.35	.94813
45	74.64	.88773	55	41.16	.95139
50	72.54	.89252	50	38.80	.95469
55	70.55	.89695	45	36.25	.95802
60	68.66	.90104	40	33.49	.96143
65	66.86	.90484	35	30.50	.96484
70	65.15	.90847	30	27.24	.96836
75	63.52	.91181	25	23.70	.97203
80	61.97	.91493	20	19.83	.97596
85	60.49	.91793	15	15.59	.98028
99	59.08	.92069	10	10.92	.98527
95	57.73	.92333	5	5.75	.99134

Temperature 75°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.			W.+Sp.		
100+ 0	100 00	.81780	100+100	56.47	.92364
5	96.52	.82878	95	55.17	.92613
10	93.21	.83851	90	53 79	.92865
15	90.07	.84710	85	52 32	.93132
20	87.12	.85496	80	50 77	.93418
25	84.34	.86212	75	49.10	.93695
30	81.71	.86864	70	47.32	.93989
35	79.22	.87466	65	45.43	.94301
40	76.88	.88018	60	43.39	.94623
45	74.67	.88538	55	41.20	.94957
50	72.57	.89018	50	38.84	.95292
55	70.58	.89464	45	36.29	.95638
60	68.68	.89872	40	33.53	.95987
65	66.89	.90252	35	30.54	.96344
70	65.18	.90617	30	27.29	.96708
75	63.55	.90952	25	23.74	.97086
80	62.00	.91270	20	19.87	.97495
85	60.52	.91569	15	15.62	.97943
90	59.11	.91849	10	10.94	.98454
95	57.76	.92111	5	5.77	.99066

TABLE I.—Continued.

Temperature 80°.

Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.	Spirit and water by weight.	Quantity of spirit per cent.	Specific gravity.
Sp.+W.						W.+Sp.					
100+100	100.00	.81530	50	72.60	.88781	100+100	56.51	.92142	50	38.89	.95111
5	96.52	.82631	55	70.61	.89225	95	55.21	.92393	45	36.34	.95467
10	93.22	.83603	60	68.71	.89639	90	53.83	.92646	40	33.58	.95826
15	90.09	.84467	65	66.92	.90021	85	52.36	.92917	35	30.59	.96192
20	87.13	.85248	70	65.21	.90385	80	50.81	.93201	30	27.33	.96568
25	84.35	.85966	75	63.59	.90723	75	49.14	.93488	25	23.79	.96963
30	81.73	.86622	80	62.04	.91046	70	47.37	.93785	20	19.91	.97385
35	79.25	.87228	85	60.56	.91340	65	45.47	.94102	15	15.65	.97845
40	76.90	.87776	90	59.15	.91622	60	43.43	.94431	10	10.97	.98367
45	74.69	.88301	95	57.80	.91891	55	41.24	.94768	5	5.78	.98991

TABLE II.—*Showing Gilpin and Blagden's densities corrected for errors of observation, and reduced to standard of Tralles.*

Temperature 30.

Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
Sp. W.				W. S.			
100+0	92.600	.83821	.83825	100+100	52.194	.94137	.94136
5	89.365	.84919	.84920	95	50.990	.94362	.94358
10	86.292	.85880	.85880	90	49 708	.94590	.94590
15	83.381	.86747	.86744	85	48.347	.94835	.94833
20	80.635	.87506	.87505	80	46.901	.95087	.95086
25	78.047	.88203	.88202	75	45 360	.95343	.95337
30	75.607	.88841	.88840	70	43.711	.95595	.95592
35	73.306	.89430	.89432	65	41.951	.95858	.95856
40	71.130	.89973	.89975	60	40.063	.96122	.96123
45	69.073	.90476	.90474	55	38 033	.96383	.96400
50	67.126	.90941	.90951	50	35 844	.96632	.96632
55	65.277	.91367	.91368	45	33.483	.96880	.96879
60	63.521	.91764	.91764	40	30.927	.97112	.97114
65	61.854	.92134	.92136	35	28.155	.97330	.97328
70	60 272	.92480	.92476	30	25 144	.97547	.97546
75	58.765	.92805	.92805	25	21.867	.97772	.97790
80	57.326	.93107	.93106	20	18.290	.98020	.98021
85	55.954	.93390	.93387	15	14 373	.98323	.98320
90	54.644	.93657	.93652	10	10.066	.98715	.98712
95	53.392	.93906	.93908	5	5.305	.99245	.99247

Temperature 35°.

100+ 0	92.600	.83597	.83597	100+100	52.194	.93940	.93940
+ 5	89.365	.84693	.84692	95	50.990	.94164	.94166
10	86 292	.85652	.85654	90	49.708	.94399	.94400
15	83.381	.86509	.86515	85	48.347	.94649	.94646
20	80 635	.87278	.87281	80	46.901	.94903	.94902
25	78 047	.87980	.87981	75	45.360	.95160	.95157
30	75.607	.88621	.88621	70	43.711	.95416	.95418
35	73.306	.89214	.89214	65	41.951	.95686	.95687
40	71.130	.89758	.89758	60	40.063	.95962	.95960
45	69 073	.90264	.90261	55	38.033	.96228	.96243
50	67.126	.90729	.90736	50	35.844	.96492	.96490
55	65.277	.91159	.91157	45	33.483	.96753	.96749
60	63.521	.91558	.91555	40	30 927	.96999	.96998
65	61.854	.91926	.91928	35	28.155	.97231	.97232
70	60.272	.92272	.92271	30	25.144	.97468	.97469
75	58.765	.92597	.92600	25	21 867	.97713	.97732
80	57.326	.92902	.92903	20	18.290	.97988	.97986
85	55.954	.93190	.93187	15	14.373	.98308	.98305
90	54.644	.93457	.93454	10	10.066	.98715	.98712
95	53.392	.93706	.93709	5	5.305	.99255	.99257

TABLE II.—Continued.

Temperature 40°.

Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
Sp. W.				W. Sp.			
100+ 0	92.600	.83370	.83367	100+100	52.194	.93743	.93741
+ 5	89.365	.84463	.84462	+ 95	50.990	.93973	.93971
10	86.292	.85430	.85426	90	49.708	.94210	.94207
15	83.381	.86283	.86285	85	48.347	.94462	.94456
20	80.635	.87056	.87055	80	46.901	.94717	.94715
25	78 047	.87759	.87758	75	45.360	.94974	.94974
30	75.607	.88401	.88400	70	43 711	.95242	.95241
35	73.306	.88993	.88994	65	41.951	.95516	.95515
40	71 130	.89536	.89539	60	40.063	.95793	.95794
45	69.073	.90046	.90046	55	38 033	.96072	.96082
50	67 126	.90514	.90519	50	35 844	.96347	.96344
55	65.277	.90944	.90944	45	33.483	.96619	.96614
60	63.521	.91346	.91343	40	30.927	.96880	.96877
65	61 854	.91716	.91717	35	28 155	.97132	.97130
70	60.272	.92068	.92063	30	25.144	.97384	.97385
75	58 765	.92393	.92393	25	21.867	.97649	.97666
80	57.326	.92700	.92698	20	18 290	.97945	.97943
85	55.954	.92988	.92984	15	14.373	.98284	.98281
90	54.644	.93257	.93253	10	10 066	.98706	.98702
95	53 392	.93508	.93508	5	5.305	.99256	.99257

Temperature 45°.

Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
100+ 0	92.600	.83139	.83135	100+100	52 194	.93537	.93540
+ 5	89 365	.84234	.84230	95	50.990	.93776	.93773
10	86 292	.85200	.85196	90	49.708	.94011	.94012
15	83 381	.86053	.86053	85	48.347	.94263	.94263
20	80.635	.86827	.86827	80	46.901	.94520	.94525
25	78 047	.87534	.87533	75	45.360	.94786	.94788
30	75.607	.88176	.88177	70	43 711	.95057	.95060
35	73.306	.88769	.88772	65	41 951	.95337	.95339
40	71.130	.89316	.89318	60	40.063	.95619	.95625
45	69.073	.89828	.89828	55	38.033	.95907	.95917
50	67.126	.90299	.90299	50	35.844	.96193	.96193
55	65.277	.90730	.90728	45	33 483	.96476	.96475
60	63.521	.91129	.91129	40	30 927	.96753	.96752
65	61.854	.91502	.91504	35	28 155	.97023	.97022
70	60 272	.91854	.91852	30	25 144	.97296	.97295
75	58 765	.92181	.92183	25	21 867	.97578	.97592
80	57 326	.92487	.92490	20	18.290	.97892	.97891
85	55 954	.92775	.92778	15	14.373	.98250	.98247
90	54.644	.93047	.93049	10	10 066	.98685	.98682
95	53 392	.93298	.93304	5	5 305	.99249	.99247

Temperature 50°.

Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
100+ 0	92.600	.82902	.82901	100+100	52.194	.93335	.93336
5	89 365	.84000	.83997	95	50.990	.93574	.93572
10	86.292	.84965	.84964	90	49.708	.93812	.93814
15	83 381	.85825	.85820	85	48.347	.94064	.94067
20	80 635	.86598	.86597	80	46 901	.94329	.94332
25	78.047	.87305	.87305	75	45 360	.94598	.94599
30	75 607	.87951	.87951	70	43.711	.94873	.94876
35	73 306	.88546	.88547	65	41.951	.95157	.95160
40	71.130	.89094	.89094	60	40 063	.95448	.95452
45	69.073	89603	.89607	55	38 033	.95745	.95749
50	67.126	.90079	.90077	50	35.844	.96040	.96038
55	65 277	.90514	.90510	45	33.483	.96333	.96332
60	63.521	.90915	.90912	40	30.927	.96621	.96622
65	61.854	.91288	.91288	35	28.155	.96908	.96908
70	60.272	.91640	.91639	30	25.144	.97196	.97198
75	58.765	.91968	.91971	25	21.867	.97501	.97510
80	57.326	.92275	.92280	20	18.290	.97832	.97831
85	55.954	.92564	.92569	15	14.373	.98205	.98204
90	54.644	.92835	.92842	10	10.066	.98656	.98653
95	53.392	.93093	.93098	5	5.305	.99227	.99227

Table II.—Continued.

Temperature 55°.

Spirit and water by weight.	Per cent.	Specific gravity	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
Sp. W.				W Sp.			
100+0	92 600	.82262	.82666	100+100	52.194	.93124	.93129
5	89 365	.83759	.83762	95	50.990	.93368	.93369
10	86.292	.84726	.84730	90	49.708	.93612	.93613
15	83.381	.85587	.85586	85	48.347	.93863	.93868
20	80 635	.86363	.86365	80	46.901	.94128	.94136
25	78.047	.87072	.87075	75	45.360	.94401	.94407
30	75.607	.87717	.87723	70	43.711	.94682	.94688
35	73.306	.88313	.88320	65	41.951	.94971	.94978
40	71.130	.88865	.88868	60	40.063	.95271	.95276
45	69.073	.89377	.89383	55	38 033	.95576	.95577
50	67 126	.89852	.89853	50	35.844	.95880	.95879
55	65.277	.90286	.90289	45	33.483	.96185	.96184
60	63.521	.90686	.90693	40	30.927	.96488	.96487
65	61.854	.91062	.91069	35	28.155	.96790	.96789
70	60 272	.91420	.91423	30	25 144	.97094	.97095
75	58.765	.91754	.91756	25	21.867	.97412	.97420
80	57.326	.92062	.92067	20	18.290	.97759	.97763
85	55.954	.92353	.92358	15	14 373	.98151	.98152
90	54.644	.92624	.92632	10	10.066	.98613	.98614
95	53.392	.92879	.92889	5	5.305	.99195	.99197

Temperature 60°.

Spirit and water by weight.	Per cent.	Specific gravity	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
100+0	92.600	.82426	.82429	100+100	52 194	.92918	.92920
5	89.365	.83524	.83525	95	50 990	.93163	.93163
10	86 292	.84492	.84494	90	49 708	.93409	.93409
15	83.381	.85353	.85350	85	48 347	.93665	.93666
20	80.635	.86130	.86131	80	46.901	.93933	.93937
25	78.047	.86840	.86843	75	45 360	.94211	.94212
30	75.607	.87490	.87493	70	43.711	.94494	.94497
35	73 306	.88090	.88091	65	41.951	.94791	.94792
40	71.130	.88640	.88640	60	40 063	.95095	.95097
45	69.073	.89152	.89156	55	38 033	.95407	.95401
50	67 126	.89626	.89626	50	35.844	.95718	.95716
55	65.277	.90063	.90066	45	33.483	.96035	.96032
60	63 521	.90468	.90471	40	30.927	.96350	.96348
65	61.854	.90845	.90848	35	28.155	.96665	.96664
70	60.272	.91205	.91204	30	25.194	.96987	.96985
75	58 765	.91539	.91539	25	21 867	.97322	.97322
80	57 326	.91850	.91851	20	18.290	.97683	.97686
85	55 954	.92142	.92144	15	14.373	.98088	.98091
90	54 644	.92416	.92419	10	10 066	.98565	.98566
95	53.392	.92675	.92677	5	5.305	.99155	.99157

Temperature 65°.

Spirit and water by weight.	Per cent.	Specific gravity	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
100+0	92 600	.82188	.82190	100+100	52 194	.92710	.92708
5	89.365	.83287	.83286	95	50.990	.92956	.92954
10	86.292	.84258	.84256	90	49.708	.93201	.93202
15	83.381	.85116	.85113	85	48 347	.93462	.93462
20	80.635	.85899	.85895	80	46.901	.93738	.93735
25	78 047	.86608	.86609	75	45 360	.94014	.94014
30	75 607	.87258	.87260	70	43.711	.94303	.94302
35	73 306	.87859	.87859	65	41.951	.94604	.94603
40	71.130	.88410	.88409	60	40.063	.94914	.94914
45	69 073	.88926	.88926	55	38.033	.95232	.95222
50	67 126	.89398	.89397	50	35 844	.95549	.95549
55	65 277	.89839	.89841	45	33.483	.95876	.95876
60	63 521	.90247	.90247	40	30 927	.96201	.96204
65	61 854	.90625	.90624	35	28.155	.96533	.96533
70	60 272	.90984	.90983	30	25.144	.96872	.96869
75	58 765	.91318	.91319	25	21.867	.97221	.97215
80	57 326	.91632	.91633	20	18 290	.97600	.97601
85	55.954	.91927	.81927	15	14.373	.98018	.98021
90	54 644	.92200	.92203	10	10.066	.98505	.98508
95	53 392	.92463	.92463	5	5.305	.99105	.99107

TABLE II.—Continued.

Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.	Spirit and water by weight.	Per cent.	Specific gravity.	Corrected specific gravity.
Temperature 70°.							
Sp W.				W. Sp.			
100+0	92.600	.81949	.81949	100+100	52 194	.92497	.92493
5	89.365	.83049	.83046	95	50.990	.92744	.92742
10	86.292	.84016	.84016	90	49.708	.92992	.92992
15	83.381	.84875	.84875	85	48.347	.93253	.93255
20	80.635	.85659	.85657	80	46 901	.93532	.93530
25	78.047	.86373	.86372	75	45 360	.93813	.93813
30	75.607	.87027	.87025	70	43.711	.94108	.94104
35	73.306	.87626	.87624	65	41 951	.94415	.94411
40	71 130	.88175	.88176	60	40 063	.94728	.94728
45	69.073	.88693	.88693	55	38.033	.95053	.95039
50	67.126	.89172	.89166	50	35 844	.95383	.95378
55	65.277	.89614	.89613	45	33.483	.95716	.95715
60	63 521	.90023	.90020	40	30.927	.96056	.96055
65	61.854	.90403	.90397	35	28 155	.96397	.96397
70	60.272	.90765	.90759	30	25.144	.96749	.96746
75	58.765	.91099	.91097	25	21 867	.97116	.97100
80	57 326	.91411	.91412	20	18.290	.97508	.97508
85	55.954	.91710	.91707	15	14 373	.97940	.97941
90	54 644	.91986	.91984	10	10.066	.98438	.98440
95	53.392	.92250	.92247	5	5.305	.99045	.99047
Temperature 75°.							
100+0	92.600	.81706	.81706	100+100	52.194	.92281	.92276
5	89.365	.82803	.82804	95	50.990	.92530	.92528
10	86 292	.83776	.83774	90	49.708	.92781	.92779
15	83.381	.84634	.84635	85	48.347	.93048	.93045
20	80.635	.85419	.85417	80	46.901	.93329	.93322
25	78 047	.86134	.86133	75	45 360	93611	.93609
30	75.607	.86786	.86787	70	43.711	.93904	.93902
35	73.306	.87387	.87387	65	41.951	.94216	.94216
40	71.130	.87939	.87940	60	40.063	.94538	.94539
45	69.073	.88458	.88458	55	38.033	.94872	.94853
50	67 126	88938	.88932	50	35 844	.95206	.95203
55	65.277	.89383	.89383	45	33.483	.95552	.95550
60	63.521	.89791	.89791	40	30.927	.95901	.95901
65	61 854	.90171	.90168	35	28.155	.96257	.96255
70	60.272	.90532	.90532	30	25.144	.96621	.96617
75	58.765	.90870	.90872	25	21 867	.96999	.96977
80	57.326	.91188	.91189	20	18 290	.97407	.97406
85	55.954	.91487	.91484	15	14.373	.97855	.97852
90	54.644	.91766	.91762	10	10 066	.98365	.98363
95	53 392	.92028	.92028	5	5.305	.98977	.98977
Temperature 80°.							
100+0	92.600	.81457	.81461	100+100	52 194	.92059	.92056
5	89 365	.82557	.82560	95	50 990	.92310	.92311
10	86 292	.83528	.83530	90	49.708	.92563	.92564
15	83.381	.84391	.84394	85	48 347	.92833	.92832
20	80.635	.85171	.85175	80	46.901	.93117	.93111
25	78 047	.85889	.85892	75	45.360	.93404	.93402
30	75.607	.86544	.86547	70	43 711	.93701	.93697
35	73 306	.87150	.87148	65	41 951	.94017	.94017
40	71.130	.87697	.87702	60	40.063	.94346	.94346
45	69 073	.88222	.88220	55	38.033	.94683	.94663
50	67.126	.88701	.88696	50	35.844	.95025	.95024
55	65 277	.89145	.89150	45	33.483	.95381	.95381
60	63.521	.89558	.89559	40	30.927	.95740	.95743
65	61.854	.89940	.89936	35	28.155	.96105	.96107
70	60.272	.90304	.90303	30	25.144	.96481	.96481
75	58 765	.90641	.90644	25	21.867	.96876	.96846
80	57.326	.90964	.90963	20	18 290	.97297	.97296
85	55.954	.91258	.91258	15	14 373	.97757	.97754
90	54.644	.91540	.91537	10	10 066	.98278	.98276
95	53.392	.91808	.91806	5	5 305	.98902	.98897

Table III.—*Showing the true densities and volumes of alcohol of every strength from 1 to 100 per cent., and for every five degrees of temperature from 30° to 100°.*

Temperature 30°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99984	1000.7	34	.96825	1009.0	68	.90737	1014.8
1	.99845	1000.8	35	.96720	1009.3	69	.90492	1014.8
2	.99706	1000 8	36	.96615	1009.6	70	.90249	1014.9
3	.99567	1000.8	37	.96509	1010.0	71	.90007	1015.0
4	.99428	1000.9	38	.96403	1010.5	72	.89758	1015.1
5	.99289	1000.9	39	.96268	1010 6	73	.89508	1015.2
6	.99169	1001.0	40	.96132	1010.8	74	.89253	1015.3
7	.99056	1001.1	41	.95991	1011 0	75	.88996	1015.4
8	.98944	1001.2	42	.95848	1011.2	76	.88738	1015.4
9	.98832	1001.4	43	.95699	1011.4	77	.88476	1015.5
10	.98719	1001.5	44	.95547	1011.7	78	.88214	1015.6
11	.98627	1001.7	45	.95393	1011 9	79	.87946	1015 8
12	.98536	1001.9	46	.95233	1012.1	80	.87676	1015.9
13	.98445	1002 1	47	.95069	1012 3	81	.87403	1016.0
14	.98354	1002.3	48	.94894	1012.4	82	.87127	1016.1
15	.98272	1002 5	49	.94716	1012.5	83	.86850	1016 3
16	.98196	1002.8	50	.94537	1012 7	84	.86561	1016.4
17	.98119	1003 1	51	.94356	1012.8	85	.86264	1016.4
18	.98043	1003.4	52	.94172	1013.1	86	.85967	1016.4
19	.97975	1003.7	53	.93983	1013.2	87	.85660	1016.5
20	.97911	1004.1	54	.93784	1013 3	88	.85347	1016.6
21	.97846	1004 5	55	.93580	1013.4	89	.85034	1016.7
22	.97780	1004.9	56	.93378	1013 5	90	.84706	1016.8
23	.97706	1005.2	57	.93173	1013.6	91	.84367	1016.8
24	.97631	1005.4	58	.92965	1013 8	92	.84028	1016 9
25	.97557	1005 7	59	.92754	1013.8	93	.83670	1017.0
26	.97484	1006.1	60	.92535	1013.9	94	.83304	1017.1
27	.97412	1006.4	61	.92320	1014.1	95	.82919	1017.1
28	.97339	1006 8	62	.92104	1014 2	96	.82511	1017.2
29	.97263	1007.2	63	.91880	1014 3	97	.82093	1017.2
30	.97186	1007.6	64	.91656	1014.3	98	.81674	1017.3
31	.97107	1008.0	65	.91431	1014.4	99	.81232	1017.4
32	.97015	1008.3	66	.91205	1014.6	100	.80776	1017.4
33	.96923	1008.6	67	.90979	1014.8			

Temperature 35°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99999		34	.96692	1007.6	68	.90523	1012.4
1	.99859	1000.9	35	.96583	1007.9	69	.90279	1012 4
2	.99719	1000.9	36	.96473	1008.2	76	.90034	1012.5
3	.99579	1001.0	37	.96360	1008 5	71	.89790	1012.6
4	.99439	1001.0	38	.96247	1008.8	72	.89541	1012.7
5	.99300	1001.0	39	.96108	1008.9	73	.89291	1012.7
6	.99178	1001.1	40	.95969	1009.1	74	.89035	1012.8
7	.99063	1001.2	41	.95824	1009.2	75	.88777	1012.8
8	.98949	1001 3	42	.95679	1009.4	76	.88518	1012.9
9	.98834	1001 4	43	.95527	1009.6	77	.88256	1013.0
10	.98720	1001.5	44	.95372	1009.8	78	.87993	1013.1
11	.98623	1001.6	45	.95214	1010.0	79	.87724	1013.2
12	.98529	1001.8	46	.95051	1010.1	80	.87453	1013.3
13	.98435	1002 0	47	.94884	1010.3	81	.87179	1013.4
14	.98340	1002.1	48	.94707	1010.4	82	.86900	1013.5
15	.98254	1002.4	49	.94528	1010.5	83	.86621	1013 6
16	.98173	1002 6	50	.94347	1010.6	84	.86332	1013.7
17	.98091	1002.8	51	.94164	1010.8	85	.86036	1013 7
18	.98010	1003 0	52	.93976	1010.9	86	.85740	1013 7
19	.97936	1003.3	53	.93785	1011.1	87	.85432	1013.8
20	.97864	1003.6	54	.93585	1011.2	88	.85120	1013 9
21	.97794	1004.0	55	.93382	1011.2	89	.84806	1013.9
22	.97721	1004.2	56	.93178	1011.3	90	.84478	1014.0
23	.97641	1004.5	57	.92970	1011.4	91	.84139	1014.1
24	.97561	1004.7	58	.92761	1011.5	92	.83800	1014.1
25	.97481	1005.0	59	.92549	1011.6	93	.83442	1014.2
26	.97401	1005 2	60	.92330	1011.7	94	.83075	1014.3
27	.97323	1005 5	61	.92113	1011.8	95	.82692	1014 3
28	.97244	1005.8	62	.91895	1011.9	96	.82283	1014.4
29	.97161	1006.1	63	.91672	1012.0	97	.81866	1014.4
30	.97076	1006 4	64	.91447	1012.0	98	.81448	1014.5
31	.96991	1006.8	65	.91220	1012.1	99	.81006	1014.5
32	.96894	1007.1	66	.90992	1012.2	100	.80550	1014.6
33	.96796	1007 3	67	.90765	1012.4			

Table III.—Continued.

Temperature 40°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	1.00000	1000.9	34	.96555	1006.2	68	.90307	1010.0
1	.99860	1000.9	35	.96441	1006.4	69	.90064	1010 0
2	.99719	1000.9	36	.96325	1006.6	70	.89818	1010.1
3	.99580	1001.0	37	.96206	1006.9	71	.89571	1910.1
4	.99440	1001.0	38	.96086	1007.1	72	.89321	1010.2
5	.99300	1001.0	39	.95945	1007.2	73	.89071	1010.2
6	.99176	1001.1	40	.95803	1007.3	74	.88815	1010 3
7	.99059	1001.1	41	.95656	1007.5	75	.88557	1010.3
8	.98943	1001.2	42	.95507	1007.6	76	.88296	1010.4
9	.98826	1001.3	43	.95352	1007.8	77	.88033	1010 5
10	.98710	1001.4	44	.95194	1007.9	78	.87770	1010.5
11	.98611	1001.5	45	.95032	1008.0	79	.87500	1010.6
12	.98513	1001.6	46	.94866	1008.2	80	.87228	1010.7
13	.98415	1001.8	47	.94697	1008.3	81	.86953	1010 8
14	.98317	1001.9	48	.94518	1008.4	82	.86672	1010 8
15	.98227	1002.0	49	.94336	1008.5	83	.86392	1010 9
16	.98141	1002.2	50	.94153	1008.6	84	.86102	1011.0
17	.98054	1002.4	51	.93969	1008.7	85	.85807	1011 0
18	.97968	1002.6	52	.93778	1008.8	86	.85512	1011.0
19	.97888	1002.8	53	.93584	1008 9	87	.85203	1011.1
20	.97811	1003.1	54	.93384	1009.0	88	.84891	1011.1
21	.97733	1003.3	55	.93180	1009.1	89	.84577	1011.2
22	.97655	1003.6	56	.92975	1009.1	90	.84248	1011.3
23	.97569	1003.7	57	.92766	1009.2	91	.83909	1011.3
24	.97483	1003.9	58	.92555	1009.3	92	.83570	1011 3
25	97397	1004.1	59	.92342	1009.3	93	.83212	1011.4
26	.97312	1004.3	60	.92123	1009.4	94	.82848	1011.5
27	.97228	1004.6	61	.91904	1009.5	95	.82461	1011.5
28	.97143	1004.8	62	.91684	1009.6	96	.82054	1011 6
29	.97053	1005.0	63	.91460	1009.6	97	.81638	1011.6
30	.96962	1005.3	64	.91234	1009.7	98	.81220	1011.7
31	.96869	1005.5	65	.91007	1009.7	99	.80778	1011.7
32	.96767	1005 7	66	.90778	1009.8	100	.80323	1011.8
33	.96664	1006.0	67	.90548	1009.9			

Temperature 45°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99993		34	.96413	1004 7	68	.90087	1007.5
1	.99852	1000.8	35	.96294	1004.9	69	.89846	1007.5
2	.99712	1000.9	36	.96173	1005.0	70	.89598	1007.6
3	.99571	1000.9	37	.96047	1005.2	71	.89350	1007.6
4	.99430	1000.9	38	.95921	1005.4	72	.89099	1007.7
5	.99290	1000.9	39	.95778	1005.5	73	.88849	1007.7
6	.99165	1000.9	40	.95634	1005.6	74	.88593	1007 8
7	.99046	1001.0	41	.95483	1005.7	75	.88334	1007 8
8	.98927	1001.1	42	.95331	1005.8	76	.88074	1007.8
9	.98808	1001.1	43	.95173	1005.9	77	.87809	1007.9
10	.98690	1001.2	44	.95012	1006.0	78	.87545	1007.9
11	.98587	1001.3	45	.94847	1006.1	79	.87273	1008 0
12	.98487	1001.4	46	.94679	1006.2	80	.87000	1008.0
13	.98386	1001.5	47	.94507	1006.3	81	.86724	1008.1
14	.98285	1001.6	48	.94326	1006 3	82	.86442	1008.1
15	.98190	1001.7	49	.94143	1006.4	83	.86160	1008.2
16	.98099	1001.8	50	.93958	1006.5	84	.85871	1008.3
17	.98008	1001.9	51	.93771	1006.5	85	.85576	1008.3
18	.97917	1002.1	52	.93578	1006.7	86	.85282	1008.3
19	.97832	1002.2	53	.93381	1006 7	87	.84973	1008 3
20	.97748	1002.4	54	.93180	1006.8	88	.84660	1008.4
21	.97664	1002.6	55	.92975	1006 8	89	.84345	1008.4
22	.97580	1002.8	56	.92769	1006 9	90	.84016	1008.5
23	.97490	1002.9	57	.92558	1006.9	91	.83677	1008.5
24	.97399	1003.1	58	.92346	1007 0	92	.83338	1008.6
25	.97308	1003.2	59	.92131	1007.0	93	.82980	1008.6
26	.97217	1003.3	60	.91912	1007.1	94	.82615	1008 6
27	.97127	1003.5	61	.91692	1007.2	95	.82230	1008 7
28	.97036	1003 7	62	.91471	1007.2	96	.81823	1008.7
29	.96940	1003.8	63	.91246	1007.3	97	.81407	1008.8
30	.96842	1004 0	64	.91020	1007 3	98	.80990	1008 8
31	.96744	1004.2	65	.90791	1007.3	99	.80548	1008.8
32	.96636	1004 4	66	.90560	1007.4	100	.80094	1008.9
33	.96527	1004.5	67	.90328	1007.5			

TABLE III.—Continued.

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Temperature 50°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99975	1000 6	34	.96268	1003.2	68	.89866	1005 0
1	.99834	1000.7	35	.96143	1003.3	69	.89625	1005.1
2	.99693	1000 7	36	.96018	1003.4	70	.89376	1005.1
3	.99552	1000.7	37	.95885	1003.5	71	.89126	1005.1
4	.99411	1000 7	38	.95753	1003.6	72	.88875	1005.1
5	.99270	1000.7	39	.95608	1003.7	73	.88624	1005 2
6	.99143	1000.7	40	.95461	1003.7	74	.88367	1005.2
7	.99023	1000 8	41	.95307	1003 8	75	.88108	1005.2
8	.98902	1000 8	42	.95152	1003.9	76	.87847	1005.3
9	.98782	1000 8	43	.94991	1004 0	77	.87582	1005.3
10	.98661	1000.9	44	.94828	1004.0	78	.87317	1005.3
11	.98556	1000.9	45	.94660	1004.1	79	.87045	1005.4
12	.98451	1001.0	46	.94488	1004.1	80	.86771	1005 4
13	.98347	1001.1	47	.94314	1004.2	81	.86493	1005 4
14	.98243	1001.1	48	.94131	1004 3	82	.86211	1005.5
15	.98144	1001.2	49	.93946	1004.3	83	.85928	1005.5
16	.98049	1001.3	50	.93759	1004 3	84	.85639	1005.5
17	.97954	1001.4	51	.93570	1004.4	85	.85344	1005 5
18	.97859	1001.5	52	.93374	1004.5	86	.85050	1005.6
19	.97767	1001.6	53	.93176	1004.5	87	.84742	1005.6
20	.97677	1001 7	54	.92974	1004 6	88	.84427	1005.6
21	.97588	1001.8	55	.92768	1004.6	89	.84112	1005.6
22	.97497	1002.0	56	.92559	1004.6	90	.83782	1005.7
23	.97402	1002 0	57	.92349	1004.6	91	.83443	1005 7
24	.97307	1002.1	58	.92135	1004.7	92	.83104	1005.7
25	.97212	1002.2	59	.91920	1004 7	93	.82746	1005 7
26	.97115	1002 3	60	.91699	1004.8	94	.82380	1005.8
27	.97019	1002.4	61	.91478	1004.8	95	.81997	1005 8
28	.96923	1002.5	62	.91255	1004.8	96	.81589	1005.8
29	.96821	1002.6	63	.91029	1004.9	97	.81174	1005 9
30	.96718	1002 7	64	.90802	1004.9	98	.80756	1005.9
31	.96614	1002 9	65	.90573	1004.9	99	.80316	1005 9
32	.96500	1003.0	66	.90341	1005.0	100	.79863	1006 0
33	.96387	1003.1	67	.90107	1005.0			

Temperature 55°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99947		34	.96117	1001.6	68	.89642	1002.5
1	.99805	1000.4	35	.95988	1001.7	69	.89401	1002 5
2	.99664	1000.4	36	.95858	1001.7	70	.89151	1002.6
3	.99523	1000.4	37	.95720	1001.8	71	.88901	1002.6
4	.99381	1000.4	38	.95582	1001,9	72	.88649	1002.6
5	.99240	1000.4	39	.95434	1001.9	73	.88397	1002.6
6	.99112	1000.4	40	.95285	1001.9	74	.88140	1002 6
7	.98990	1000.4	41	.95128	1001.9	75	.87880	1002 6
8	.98867	1000.5	42	.94970	1002.0	76	.87618	1002.6
9	.98745	1000.5	43	.94805	1002.0	77	.87353	1002.7
10	.98622	1000.5	44	.94639	1002 0	78	.87087	1002.7
11	.98513	1000.5	45	.94468	1002.1	79	.86814	1002.7
12	.98407	1000.5	46	.94294	1002 1	80	.86539	1002 7
13	.98299	1000 6	47	.94117	1002 1	81	.86261	1002.7
14	.98192	1000.6	48	.93932	1002.1	82	.85978	1002 7
15	.98090	1000 6	49	.93746	1002.2	83	.85694	1002 8
16	.97991	1000.7	50	.93557	1002.2	84	.85405	1002 8
17	.97891	1000 7	51	.93367	1002.2	85	.85110	1002 8
18	.97792	1000.8	52	.93168	1002.2	86	.84816	1002 8
19	.97695	1000.8	53	.92968	1002.3	87	.84507	1002.8
20	.97599	1000.9	54	.92764	1002 3	88	.84192	1002 8
21	.97503	1001.0	55	.92558	1002.3	89	.83877	1002.8
22	.97407	1001.0	56	.92348	1002.3	90	.83547	1002.8
23	.97308	1001.1	57	.92136	1002.3	91	.83208	1002 9
24	.97209	1001.1	58	.91921	1002.4	92	.82869	1002 9
25	.97109	1001.1	59	.91704	1002.4	93	.82511	1002.9
26	.97008	1001.2	60	.91483	1002.4	94	.82146	1002.9
27	.96906	1001.2	61	.91260	1002.4	95	.81763	1002 9
28	.96805	1001.3	62	.91036	1002.4	96	.81356	1002 9
29	.96697	1001.3	63	.90810	1002.4	97	.80941	1002 9
30	.96588	1001.4	64	.90583	1002.5	98	.80523	1003.0
31	.96478	1001.4	65	.90353	1002.5	99	.80082	1003.0
32	.96360	1001 5	66	.90118	1002.5	100	.79630	1003 0
33	.96241	1001.5	67	.89883	1002.5			

TABLE III.—Continued.

Temperature 60°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99910	1000.0	34	.95963	1000.0	68	.89415	1000.0
1	.99768	1000.0	35	.95829	1000.0	69	.89174	1000.0
2	.99626	1000 0	36	.95693	1000.0	70	.88923	1000.0
3	.99484	1000.0	37	.95549	1000 0	71	.88673	1000.0
4	.99342	1000 0	38	.95406	1000.0	72	.88420	1000 0
5	.99200	1000.0	39	.95256	1000.0	73	.88168	1000.0
6	.99071	1000.0	40	.95106	1000 0	74	.87911	1000 0
7	.98947	1000 0	41	.94946	1000 0	75	.87651	1000.0
8	.98822	1000.0	42	.94784	1000.0	76	.87388	1000.0
9	.98698	1000.0	43	.94616	1000 0	77	.87122	1000.0
10	.98574	1000.0	44	.94447	1000.0	78	.86855	1000.0
11	.98463	1000 0	45	.94274	1000.0	79	.86581	1000.0
12	.98353	1000.0	46	.94098	1000.0	80	.86306	1000 0
13	.98242	1000 0	47	.93918	1000.0	81	.86027	1000 0
14	.98132	1000.0	48	.93731	1000.0	82	.85743	1000 0
15	.98026	1000.0	49	.93543	1000 0	83	.85458	1000.0
16	.97923	1000.0	50	.93353	1000.0	84	.85168	1000.0
17	.97819	1000.0	51	.93161	1000.0	85	.84874	1000.0
18	.97716	1000 0	52	.92959	1000.0	86	.84580	1000 0
19	.97614	1000.0	53	.92756	1000.0	87	.84271	1000.0
20	.97512	1000.0	54	.92552	1000.0	88	.83955	1000.0
21	.97410	1000 0	55	.92344	1000.0	89	.83640	1000 0
22	.97308	1000.0	56	.92134	1000.0	90	.83310	1000.0
23	.97205	1000.0	57	.91921	1000.0	91	.82971	1000.0
24	.97103	1000.0	58	.91705	1000.0	92	.82632	1000 0
25	.97000	1000.0	59	.91487	1000 0	93	.82274	1000 0
26	.96894	1000.0	60	.91264	1000.0	94	.81907	1000.0
27	.96787	1000.0	61	.91040	1000.0	95	.81525	1000.0
28	.96680	1000.0	62	.90815	1000.0	96	.81117	1000 0
29	.96568	1000.0	63	.90589	1000.0	97	.80703	1000.0
30	.96454	1000.0	64	.90360	1000.0	98	.80284	1000 0
31	.96339	1000.0	65	.90130	1000.0	99	.79846	1000 0
32	.96215	1000 0	66	.89894	1000.0	100	.79390	1000 0
33	.96092	1000.0	67	.89656	1000.0			

Temperature 65°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99863		34	.95804	998.3	68	.89185	997 4
1	.99721	999.5	35	.95666	998 3	69	.88944	997.4
2	.99578	999.5	36	.95525	998.2	70	.88693	997.4
3	.99435	999.5	37	.95376	998.2	71	.88442	997.4
4	.99293	999.5	38	.95227	998.1	72	.88189	997 4
5	.99150	999.5	39	.95075	998.1	73	.87936	997.4
6	.99020	999.5	40	.94923	998.1	74	.87679	997 4
7	.98893	999.5	41	.94760	998.0	75	.87418	997 3
8	.98768	999.4	42	.94594	998.0	76	.87155	997.3
9	.98642	999.4	43	.94424	998.0	77	.86888	997.3
10	.98516	999.4	44	.94252	997.9	78	.86622	997 3
11	.98402	999.4	45	.94077	997.9	79	.86346	997.3
12	.98290	999 4	46	.93898	997.9	80	.86070	997.3
13	.98176	999.3	47	.93716	997.9	81	.85791	997.3
14	.98063	999.3	48	.93527	997.8	82	.85507	997.3
15	.97953	999 2	49	.93337	997 8	83	.85221	997.2
16	.97846	999.2	50	.93145	997 8	84	.84931	997.2
17	.97739	999.2	51	.92952	997.8	85	.84636	997.2
18	.97632	999.1	52	.92748	997.7	86	.84342	997.2
19	.97524	999.1	53	.92543	997 7	87	.84032	997.2
20	.97416	999.0	54	.92337	997.7	88	.83717	997.2
21	.97309	999 0	55	.92128	997 7	89	.83401	997 1
22	.97201	998.9	56	.91917	997.6	90	.83071	997.1
23	.97095	998 9	57	.91703	997.6	91	.82732	997.1
24	.96990	998.8	58	.91486	997.6	92	.82393	997.1
25	.96884	998.8	59	.91267	997 6	93	.82035	997.1
26	.96773	998.8	60	.91044	997.6	94	.81670	997 1
27	.96662	998.7	61	.90818	997.6	95	.81287	997.1
28	.96550	998.7	62	.90591	997 5	96	.80879	997.1
29	.96433	998 6	63	.90365	997.5	97	.80465	997.1
30	.96314	998.6	64	.90136	997.5	98	.80048	997.1
31	.96194	998.5	65	.89905	997.5	99	.79608	997.1
32	.96066	998.5	66	.89667	997.5	100	.79156	997.1
33	.95938	998.4	67	.89427	997.5			

TABLE III.—Continued.

Temperature 70°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume
0	.99807	999.0	34	.95641	996.7	68	.88954	994.8
1	.99664	999.0	35	.95499	996.6	69	.88711	994.8
2	.99520	998.9	36	.95354	996.5	70	.88460	994.8
3	.99377	998.9	37	.95199	996.3	71	.88209	994.8
4	.99234	998.9	38	.95044	996.2	72	.87955	994.7
5	.99091	998.9	39	.94891	996.2	73	.87702	994.7
6	.98959	998.9	40	.94737	996.1	74	.87444	994.7
7	.98831	998.8	41	.94571	996.1	75	.87183	994.7
8	.98704	998.8	42	.94403	996.0	76	.86920	994.6
9	.98576	998.8	43	.94228	995.9	77	.86652	994.6
10	.98448	998.7	44	.94053	995.8	78	.86385	994.6
11	.98332	998.7	45	.93877	995.8	79	.86109	994.6
12	.98216	998.6	46	.93696	995.7	80	.85832	994.5
13	.98100	998.6	47	.93511	995.7	81	.85553	994.5
14	.97984	998.5	48	.93321	995.6	82	.85269	994.5
15	.97872	998.4	49	.93129	995.6	83	.84983	994.4
16	.97761	998.4	50	.92935	995.5	84	.84692	994.4
17	.97651	998.3	51	.92740	995.5	85	.84397	994.4
18	.97540	998.2	52	.92533	995.4	86	.84102	994.4
19	.97427	998.1	53	.92328	995.4	87	.83792	994.3
20	.97313	998.0	54	.92119	995.3	88	.83477	994.3
21	.97199	997.8	55	.91909	995.3	89	.83161	994.3
22	.97086	997.7	56	.91697	995.3	90	.82830	994.2
23	.96978	997.7	57	.91482	995.2	91	.82491	994.2
24	.96870	997.6	58	.91264	995.2	92	.82152	994.2
25	.96762	997.6	59	.91044	995.2	93	.81794	994.2
26	.96647	997.5	60	.90820	995.1	94	.81428	994.2
27	.96531	997.4	61	.90592	995.1	95	.81046	994.1
28	.96415	997.3	62	.90364	995.0	96	.80640	994.1
29	.96293	997.2	63	.90138	995.0	97	.80224	994.1
30	.96169	997.1	64	.89909	995.0	98	.79808	994.1
31	.96045	997.0	65	.89677	995.0	99	.79368	994.0
32	.95912	996.9	66	.89438	994.9	100	.78917	994.0
33	.95779	996.7	67	.89196	994.9			

Temperature 75°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume
0	.99741		34	.95474	994.9	68	.88719	992.2
1	.99596	998.3	35	.95327	994.7	69	.88476	992.2
2	.99453	998.3	36	.95178	994.6	70	.88224	992.1
3	.99309	998.2	37	.95018	994.4	71	.87973	992.1
4	.99165	998.2	38	.94858	994.3	72	.87719	992.1
5	.99021	998.2	39	.94703	994.2	73	.87465	992.0
6	.98888	998.2	40	.94548	994.1	74	.87206	992.0
7	.98758	998.1	41	.94379	994.0	75	.86945	992.0
8	.98630	998.1	42	.94207	993.9	76	.86681	991.9
9	.98500	998.0	43	.94029	993.8	77	.86414	991.9
10	.98372	998.0	44	.93851	993.7	78	.86146	991.8
11	.98252	997.9	45	.93673	993.6	79	.85869	991.8
12	.98134	997.8	46	.93490	993.5	80	.85593	991.7
13	.98015	997.7	47	.93303	993.5	81	.85313	991.7
14	.97896	997.6	48	.93112	993.4	82	.85029	991.7
15	.97781	997.5	49	.92917	993.3	83	.84743	991.6
16	.97667	997.4	50	.92722	993.2	84	.84452	991.6
17	.97553	997.3	51	.92526	993.1	85	.84156	991.5
18	.97439	997.2	52	.92317	993.1	86	.83860	991.5
19	.97321	997.0	53	.92109	993.0	87	.83550	991.4
20	.97201	996.8	54	.91899	992.9	88	.83235	991.4
21	.97081	996.6	55	.91686	992.9	89	.82919	991.4
22	.96962	996.5	56	.91474	992.8	90	.82589	991.4
23	.96853	996.4	57	.91259	992.8	91	.82249	991.3
24	.96743	996.3	58	.91041	992.8	92	.81910	991.3
25	.96633	996.2	59	.90819	992.7	93	.81551	991.2
26	.96514	996.1	60	.90593	992.7	94	.81185	991.2
27	.96394	995.9	61	.90364	992.6	95	.80802	991.2
28	.96274	995.8	62	.90135	992.5	96	.80397	991.2
29	.96147	995.6	63	.89909	992.5	97	.79982	991.1
30	.96019	995.5	64	.89679	992.5	98	.79565	991.0
31	.95891	995.4	65	.89447	992.4	99	.79126	991.0
32	.95754	995.2	66	.89207	992.4	100	.78675	991.0
33	.95616	995.1	67	.88963	992.3			

TABLE III.—Continued.

Temperature 80°.

Per cent.	Density.	Volume.	Per cent	Density.	Volume.	Per cent	Density.	Volume.
0	.99666	997.5	34	.95303	993.1	68	.88482	989.6
1	.99521	997.5	35	.95152	992.9	69	.88238	989.5
2	.99376	997.5	36	.94998	992.7	70	.87986	989.5
3	.99231	997.5	37	.94833	992.5	71	.87735	989.4
4	.99086	997.4	38	.94668	992.3	72	.87481	989.4
5	.98941	997.4	39	.94512	992.2	73	.87226	989.3
6	.98806	997.3	40	.94355	992.1	74	.86967	989.3
7	.98676	997.3	41	.94183	992.0	75	.86705	989.2
8	.98546	997.2	42	.94008	991.8	76	.86442	989.2
9	.98415	997.1	43	.93826	991.7	77	.86173	989.1
10	.98285	997.1	44	.93645	991.5	78	.85905	989.1
11	.98163	997.0	45	.93466	991.4	79	.85628	989.0
12	.98042	996.8	46	.93281	991.3	80	.85351	988.9
13	.97920	996.7	47	.93092	991.2	81	.85072	988.9
14	.97799	996.6	48	.92899	991.1	82	.84787	988.9
15	.97681	996.5	49	.92703	991.0	83	.84502	988.8
16	.97564	996.3	50	.92506	990.9	84	.84211	988.8
17	.97447	996.2	51	.92309	990.9	85	.83914	988.7
18	.97330	996.1	52	.92097	990.7	86	.83617	988.6
19	.97207	995.8	53	.91888	990.6	87	.83306	988.6
20	.97081	995.6	54	.91675	990.5	88	.82991	988.5
21	.96955	995.3	55	.91461	990.5	89	.82675	988.5
22	.96831	995.1	56	.91248	990.4	90	.82344	988.4
23	.96720	995.0	57	.91033	990.3	91	.82004	988.3
24	.96608	994.9	58	.90813	990.3	92	.81665	988.3
25	.96497	994.8	59	.90591	990.2	93	.81306	988.2
26	.96375	994.6	60	.90365	990.2	94	.80941	988.2
27	.96251	994.5	61	.90134	990.1	95	.80558	988.2
28	.96126	994.3	62	.89903	990.0	96	.80152	988.1
29	.95996	994.1	63	.89677	989.9	97	.79738	988.0
30	.95865	993.9	64	.89447	989.9	98	.79320	988.0
31	.95733	993.7	65	.89215	989.9	99	.78882	987.9
32	.95591	993.5	66	.88973	989.8	100	.78432	987.9
33	.95449	993.3	67	.88727	989.6			

Temperature 85°.

Per cent.	Density.	Volume.	Per cent	Density.	Volume.	Per cent	Density.	Volume.
0	.99581		34	.95126	991.3	68	.88243	986.9
1	.99435	996.7	35	.94971	991.1	69	.87997	986.8
2	.99289	996.6	36	.94813	990.8	70	.87746	986.8
3	.99143	996.6	37	.94644	990.5	71	.87495	986.7
4	.98997	996.5	38	.94475	990.2	72	.87240	986.7
5	.98851	996.5	39	.94317	990.1	73	.86985	986.6
6	.98716	996.4	40	.94159	990.0	74	.86726	986.5
7	.98584	996.3	41	.93984	989.9	75	.86464	986.5
8	.98452	996.3	42	.93806	989.7	76	.86200	986.4
9	.98320	996.2	43	.93620	989.5	77	.85930	986.3
10	.98189	996.1	44	.93436	989.3	78	.85662	986.3
11	.98065	996.0	45	.93257	989.2	79	.85385	986.2
12	.97941	995.8	46	.93070	989.1	80	.85107	986.1
13	.97817	995.7	47	.92878	988.9	81	.84828	986.1
14	.97693	995.5	48	.92683	988.8	82	.84544	986.0
15	.97572	995.4	49	.92487	988.7	83	.84260	986.0
16	.97452	995.2	50	.92288	988.6	84	.83968	985.9
17	.97333	995.0	51	.92089	988.5	85	.83669	985.8
18	.97213	994.9	52	.91875	988.3	86	.83371	985.7
19	.97085	994.6	53	.91664	988.2	87	.83060	985.6
20	.96953	994.3	54	.91449	988.1	88	.82745	985.6
21	.96821	994.0	55	.91233	988.0	89	.82429	985.5
22	.96692	993.7	56	.91019	987.9	90	.82097	985.4
23	.96580	993.6	57	.90805	987.9	91	.81759	985.4
24	.96468	993.5	58	.90585	987.8	92	.81418	985.3
25	.96355	993.4	59	.90361	987.7	93	.81059	985.2
26	.96229	993.1	60	.90133	987.6	94	.80692	985.2
27	.96101	992.9	61	.89901	987.5	95	.80310	985.1
28	.95973	992.7	62	.89668	987.4	96	.79904	985.1
29	.95839	992.5	63	.89442	987.4	97	.79489	985.0
30	.95705	992.2	64	.89213	987.3	98	.79074	984.9
31	.95569	992.0	65	.88980	987.2	99	.78636	984.8
32	.95423	991.8	66	.88737	987.1	100	.78185	984.8
33	.95277	991.5	67	.88489	987.0			

TABLE III.—Continued.

Temperature 90°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99487	995.7	34	.94946	989.4	68	.88000	984.2
1	.99339	995.7	35	.94787	989.1	69	.87753	984.1
2	.99193	995.7	36	.94625	988.8	70	.87502	984.0
3	.99046	995.6	37	.94451	988.5	71	.87252	984.0
4	.98899	995.5	38	.94278	988.2	72	.86996	983.9
5	.98752	995.5	39	.94119	988.1	73	.86741	983.8
6	.98615	995.4	40	.93960	988.0	74	.86481	983.7
7	.98481	995.3	41	.93782	987.7	75	.86219	983.7
8	.98349	995.2	42	.93600	987.5	76	.85954	983.6
9	.98216	995.1	43	.93411	987.3	77	.85685	983.5
10	.98083	995.0	44	.93224	987.1	78	.85416	983.4
11	.97957	994.9	45	.93044	987.0	79	.85139	983.3
12	.97830	994.7	46	.92855	986.8	80	.84861	983.3
13	.97704	994.5	47	.92661	986.6	81	.84581	983.2
14	.97578	994.4	48	.92465	986.5	82	.84299	983.2
15	.97454	994.2	49	.92267	986.4	83	.84016	983.1
16	.97332	994.0	50	.92067	986.2	84	.83723	983.0
17	.97209	993.8	51	.91866	986.1	85	.83423	982.9
18	.97086	993.6	52	.91650	985.9	86	.83123	982.8
19	.96954	993.2	53	.91438	985.8	87	.82812	982.7
20	.96816	992.9	54	.91221	985.6	88	.82497	982.6
21	.96679	992.5	55	.91002	985.5	89	.82181	982.6
22	.96545	992.2	56	.90787	985.4	90	.81850	982.5
23	.96432	992.1	57	.90574	985.3	91	.81510	982.4
24	.96319	991.9	58	.90353	985.3	92	.81169	982.3
25	.96206	991.8	59	.90127	985.1	93	.80810	982.2
26	.96077	991.6	60	.89899	985.0	94	.80444	982.1
27	.95946	991.3	61	.89665	984.9	95	.80062	982.0
28	.95814	991.0	62	.89431	984.8	96	.79655	981.9
29	.95677	990.8	63	.89205	984.7	97	.79241	981.8
30	.95540	990.5	64	.88976	984.7	98	.78826	981.7
31	.95401	990.3	65	.88743	984.6	99	.78388	981.7
32	.95251	990.0	66	.88498	984.5	100	.77937	981.6
33	.95101	989.7	67	.88248	984.3			

Temperature 95°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99383		34	.94762	987.5	68	.87756	981.5
1	.99235	994.7	35	.94598	987.2	69	.87506	981.3
2	.99087	994.6	36	.94432	986.8	70	.87256	981.3
3	.98938	994.5	37	.94255	986.5	71	.87007	981.2
4	.98790	994.4	38	.94077	986.1	72	.86751	981.1
5	.98642	994.4	39	.93917	985.9	73	.86495	981.0
6	.98504	994.3	40	.93758	985.8	74	.86235	980.9
7	.98369	994.2	41	.93576	985.6	75	.85972	980.8
8	.98235	994.1	42	.93391	985.3	76	.85707	980.8
9	.98101	994.0	43	.93198	985.0	77	.85437	980.7
10	.97967	993.8	44	.93008	984.8	78	.85168	980.6
11	.97839	993.7	45	.92828	984.7	79	.84891	980.5
12	.97710	993.5	46	.92637	984.5	80	.84613	980.4
13	.97581	993.3	47	.92440	984.3	81	.84334	980.3
14	.97453	993.1	48	.92243	984.1	82	.84052	980.3
15	.97327	992.9	49	.92044	984.0	83	.83770	980.3
16	.97202	992.6	50	.91843	983.8	84	.83476	980.1
17	.97077	992.4	51	.91641	983.7	85	.83175	980.0
18	.96952	992.2	52	.91422	983.5	86	.82874	979.8
19	.96814	991.8	53	.91209	983.3	87	.82562	979.7
20	.96672	991.4	54	.90989	983.1	88	.82247	979.7
21	.96529	991.0	55	.90768	982.9	89	.81931	979.6
22	.96390	990.6	56	.90552	982.8	90	.81599	979.5
23	.96277	990.5	57	.90340	982.8	91	.81259	979.4
24	.96164	990.3	58	.90119	982.7	92	.80918	979.3
25	.96051	990.2	59	.89892	982.6	93	.80559	979.2
26	.95919	989.9	60	.89663	982.5	94	.80193	979.1
27	.95785	989.7	61	.89427	982.3	95	.79810	979.0
28	.95650	989.3	62	.89191	982.1	96	.79405	979.0
29	.95510	989.0	63	.88966	982.1	97	.78991	978.8
30	.95370	988.8	64	.88737	982.0	98	.78576	978.7
31	.95229	988.5	65	.88503	982.0	99	.78138	978.6
32	.95075	988.2	66	.88256	981.8	100	.77688	978.6
33	.94921	987.8	67	.88006	981.6			

TABLE III.—Continued.

Temperature 100°.

Per cent.	Density.	Volume.	Per cent.	Density.	Volume.	Per cent.	Density.	Volume.
0	.99270	993.6	34	.94573	985.5	68	.87508	978.7
1	.99121	993.5	35	.94406	985.2	69	.87256	978.5
2	.98971	993.4	36	.94236	984.8	70	.87008	978.5
3	.98821	993.3	37	.94054	984.4	71	.86759	978.4
4	.98672	993.3	38	.93872	983.9	72	.86504	978.3
5	.98523	993.2	39	.93712	983.8	73	.86248	978.2
6	.98383	993.1	40	.93552	983.7	74	.85987	978.1
7	.98248	992.9	41	.93367	983.4	75	.85724	978.0
8	.98112	992.9	42	.93179	983.1	76	.85458	977.9
9	.97977	992.7	43	.92982	982.7	77	.85187	977.8
10	.97842	992.6	44	.92789	982.5	78	.84918	977.7
11	.97711	992.4	45	.92609	982.3	79	.84641	977.6
12	.97580	992.1	46	.92416	982.1	80	.84363	977.5
13	.97449	991.9	47	.92218	981.9	81	.84085	977.4
14	.97319	991.7	48	.92020	981.8	82	.83804	977.4
15	.97191	991.5	49	.91819	981.6	83	.83524	977.4
16	.97063	991.2	50	.91616	981.4	84	.83229	977.2
17	.96937	991.0	51	.91413	981.2	85	.82926	977.1
18	.96810	990.7	52	.91192	981.0	86	.82623	976.9
19	.96668	990.3	53	.90977	980.8	87	.82310	976.7
20	.96519	989.8	54	.90755	980.6	88	.81995	976.7
21	.96371	989.3	55	.90531	980.4	89	.81679	976.6
22	.96227	988.9	56	.90316	980.3	90	.81348	976.5
23	.96115	988.8	57	.90104	980.2	91	.81007	976.3
24	.96002	988.7	58	.89882	980.1	92	.80666	976.2
25	.95889	988.6	59	.89654	980.0	93	.80306	976.1
26	.95755	988.2	60	.89423	979.8	94	.79939	976.0
27	.95617	987.9	61	.89186	979.6	95	.79556	975.8
28	.95479	987.6	62	.88948	979.4	96	.79150	975.7
29	.95338	987.3	63	.88724	979.4	97	.78737	975.6
30	.95195	987.0	64	.88495	979.4	98	.78322	975.5
31	.95051	986.6	65	.88261	979.3	99	.77886	975.4
32	.94894	986.3	66	.88013	979.1	100	.77435	975.4
33	.94736	985.9	67	.87761	978.9			

SUPPLEMENT TO TABLE III.—*Giving specific gravities for temperatures between 0° and 25°, observed by Dr. Recknagel, and reduced to Tralles' standard.*

Per cent.	Specific gravity.			Per cent.	Specific gravity.		
	0°	5°	10°		15°	20°	25°
30	.9772	.9763	.9755	30	.9746	.9737	.9728
31	.9770	.9761	.9751	31	.9741	.9731	.9721
32	.9767	.9757	.9746	32	.9736	.9725	.9714
33	.9762	.9751	.9740	33	.9729	.9717	.9705
34	.9757	.9745	.9733	34	.9721	.9708	.9696
35	.9750	.9738	.9725	35	.9712	.9700	.9687
36	.9744	.9731	.9718	36	.9704	.9690	.9677
37	.9736	.9723	.9709	37	.9695	.9682	.9668
38	.9728	.9714	.9700	38	.9686	.9671	.9656
39	.9719	.9705	.9690	39	.9675	.9659	.9644
40	.9708	.9694	.9678	40	.9663	.9647	.9632
41	.9699	.9683	.9667	41	.9651	.9635	.9619
42	.9687	.9671	.9654	42	.9638	.9621	.9604
43	.9674	.9657	.9640	43	.9624	.9606	.9589
44	.9660	.9643	.9626	44	.9608	.9591	.9573
45	.9645	.9628	.9611	45	.9593	.9576	.9558
46	.9631	.9613	.9596	46	.9578	.9560	.9542
47	.9616	.9598	.9580	47	.9562	.9544	.9526
48	.9600	.9582	.9564	48	.9546	.9528	.9509
49	.9584	.9566	.9548	49	.9529	.9511	.9492
50	.9568	.9549	.9531	50	.9512	.9493	.9474
51	.9551	.9532	.9513	51	.9494	.9475	.9456
52	.9533	.9514	.9495	52	.9476	.9457	.9437
53	.9514	.9495	.9476	53	.9457	.9438	.9418
54	.9496	.9476	.9457	54	.9438	.9418	.9398
55	.9477	.9457	.9438	55	.9418	.9398	.9378
56	.9457	.9437	.9418	56	.9398	.9377	.9357
57	.9436	.9416	.9397	57	.9377	.9357	.9337
58	.9416	.9396	.9377	58	.9357	.9336	.9316
59	.9395	.9375	.9356	59	.9336	.9315	.9295
60	.9375	.9355	.9335	60	.9315	.9294	.9274
61	.9354	.9334	.9314	61	.9294	.9273	.9253
62	.9333	.9313	.9292	62	.9272	.9251	.9231
63	.9312	.9291	.9270	63	.9250	.9229	.9209
64	.9290	.9269	.9248	64	.9228	.9207	.9187
65	.9268	.9247	.9226	65	.9206	.9185	.9164
66	.9246	.9225	.9204	66	.9184	.9162	.9141
67	.9223	.9202	.9181	67	.9161	.9139	.9118
68	.9200	.9179	.9158	68	.9138	.9116	.9095
69	.9177	.9156	.9135	69	.9115	.9093	.9072
70	.9153	.9132	.9111	70	.9091	.9069	.9048
71	.9129	.9108	.9087	71	.9067	.9045	.9024
72	.9105	.9084	.9063	72	.9042	.9020	.8999
73	.9080	.9059	.9038	73	.9017	.8995	.8974
74	.9056	.9034	.9013	74	.8992	.8970	.8948
75	.9031	.9009	.8988	75	.8967	.8945	.8923
76	.9006	.8984	.8963	76	.8942	.8919	.8897
77	.8980	.8958	.8937	77	.8916	.8893	.8871
78	.8954	.8932	.8911	78	.8890	.8867	.8845
79	.8928	.8906	.8884	79	.8863	.8840	.8818
80	.8901	.8879	.8857	80	.8836	.8813	.8791
81	.8874	.8852	.8830	81	.8809	.8786	.8764
82	.8847	8825	.8803	82	.8782	.8759	.8736
83	.8819	.8797	.8775	83	.8754	.8731	.8708
84	.8790	.8768	.8746	84	.8725	.8702	.8679
85	.8761	.8739	.8717	85	.8696	.8673	.8650
86	.8731	.8709	.8687	86	.8666	.8643	.8621
87	.8701	.8679	.8657	87	.8635	.8612	.8590
88	.8670	.8648	.8626	88	.8604	.8581	.8559
89	.8638	.8616	.8594	89	.8572	.8549	.8527
90	.8606	.8583	.8561	90	.8539	.8516	.8494
91	.8573	.8550	.8528	91	.8506	.8483	.8461
92	.8540	.8517	.8494	92	.8471	.8449	.8427
93	.8506	.8483	.8460	93	.8437	.8415	.8392
94	.8470	.8448	.8425	94	.8402	.8380	.8357
95	.8433	.8411	.8388	95	.8365	.8343	.8320
96	.8394	.8372	.8349	96	.8326	.8304	.8281
97	.8353	.8331	.8308	97	.8284	.8262	.8239
98	.8310	.8287	.8264	98	.8240	.8218	.8195
99	.8264	.8241	.8218	99	.8194	.8172	.8149
100	.8215	.8192	.8169	100	.8145	.8123	.8100

TABLE IV.—*Showing the apparent densities and apparent per cents., corresponding to every true per cent. from 1 to 100, and for every fifth degree of temperature from 30° to 100.°*

Temperature 30°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99945	—0.25	34	.96788	26.99	68	.90702	62 50
1	.99806	+0 73	35	.96683	27.97	69	.90457	63.57
2	.99667	1.71	36	.96578	28 91	70	.90214	64.63
3	.99528	2.69	37	.96472	29.84	71	.89972	65.67
4	.99390	3 66	38	.96366	30.77	72	.89723	66.72
5	.99251	4.64	39	.96231	31.87	73	.89473	67.76
6	.99131	5.54	40	.96095	32 98	74	.89218	68.82
7	.99018	6.43	41	.95954	34.07	75	.88962	69 84
8	.98906	7 33	42	.95811	35.13	76	.88704	70.88
9	.98794	8.23	43	.95662	36.22	77	.88442	71.91
10	.98681	9.14	44	.95510	37.27	78	.88180	72.95
11	.98589	9.89	45	.95356	38 33	79	.87912	74.00
12	.98498	10.69	46	.95196	39.40	80	.87642	75.03
13	.98407	11.51	47	.95032	40.46	81	.87369	76 07
14	.98316	12.33	48	.94857	41.55	82	.87093	77 11
15	.98234	13.07	49	.94679	42.63	83	.86816	78 14
16	.98158	13.76	50	.94500	43.69	84	.86528	79.19
17	.98081	14.48	51	.94320	44.73	85	.86231	80.27
18	.98005	15.20	52	.94136	45.78	86	.85934	81.33
19	.97937	15.86	53	.93947	46 84	87	.85627	82.41
20	.97873	16.48	54	.93748	47.91	88	.85314	83.50
21	.97808	17.11	55	.93544	48.99	89	.85001	84.57
22	.97742	17.75	56	.93342	50.07	90	.84673	85.68
23	.97668	18.47	57	.93137	51.12	91	.84334	86.80
24	.97593	19.21	58	.92929	52.15	92	.83995	87.87
25	.97519	19.93	59	.92718	53.19	93	.83638	89.01
26	.97446	20.65	60	.92499	54.25	94	.83272	90.11
27	.97374	21.35	61	.92284	55 29	95	.82887	91.25
28	.97301	22 07	62.	.92068	56.31	96	.82479	92.45
29	.97225	22.81	63	.91844	57.36	97	.82061	93 61
30	.97148	23.56	64	.91621	58 39	98	.81642	94 71
31	.97069	24 33	65	.91396	59.41	99	.81201	95.81
32	.96977	25.22	66	.91170	60.42	100	.80745	96.92
33	.96886	26 08	67	.90944	61.43			

Temperature 35°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99967	—0.40	34	.96661	28.17	68	.90494	63.42
1	.99827	+0.58	35	.96552	29.14	69	.90250	64.48
2	.99687	1.57	36	.96442	30 10	70	.90005	65.53
3	.99547	2.55	37	.96329	31.09	71	.89761	66.56
4	.99407	3.54	38	.96216	31.99	72	.89512	67 60
5	.99268	4.52	39	.96077	33 12	73	.89262	68 63
6	.99146	5.42	40	.95938	34.19	74	.89006	69 67
7	.99031	6.32	41	.95793	35 26	75	.88748	70.70
8	.98917	7.24	42	.95648	36.31	76	.88489	71.73
9	.98802	8.16	43	.95496	37.37	77	.88228	72 76
10	.98688	9.09	44	.95341	38 43	78	.87965	73 79
11	.98591	9.87	45	.95183	39 49	79	.87696	74 83
12	.98497	10.69	46	.95020	40 54	80	.87425	75 86
13	.98403	11.55	47	.94853	41.57	81	.87151	76 89
14	.98308	12 41	48	.94676	42.64	82	.86872	77 94
15	.98222	13.18	49	.94498	43.70	83	.86593	78 96
16	.98141	13.92	50	.94317	44 75	84	.86304	80 01
17	.98059	14.69	51	.94134	45.80	85	.86008	81 07
18	.97978	15.47	52	.93946	46.85	86	.85712	82.11
19	.97904	16.18	53	.93755	47.87	87	.85404	83.19
20	.97832	16.88	54	.93555	48.94	88	.85093	84.26
21	.97762	17 55	55	.93352	50.01	89	.84779	85 32
22	.97690	18.25	56	.93148	51.07	90	.84451	86.42
23	.97610	19.04	57	.92940	52.09	91	.84112	87.50
24	.97530	19.82	58	.92731	53.12	92	.83773	88 58
25	.97450	20.61	59	.92519	54.16	93	.83415	89.68
26	.97370	21.39	60	.92300	55 21	94	.83048	90 77
27	.97292	22.16	61	.92083	56.24	95	.82665	91 90
28	.97213	22.92	62	.91865	57.26	96	.82256	93.09
29	.97130	23 74	63	.91642	58 29	97	.81840	94.19
30	.97045	24.56	64	.91418	59 31	98	.81422	95.26
31	.96960	25.28	65	.91191	60.33	99	.80980	96.35
32	.96863	26.29	66	.90963	61 34	100	.80524	97.44
33	.96765	27 21	67	.90736	62.35			

TABLE IV.—Continued.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
				Temperature 40°.				
0	.99974	—0.45	34	.96530	29.33	68	.90284	64.33
1	.99834	+0.54	35	.96416	30.33	69	.90041	65.38
2	.99693	1.53	36	.96300	31.31	70	.89795	66.42
3	.99554	2.51	37	.96181	32.28	71	.89548	67.45
4	.99414	3.49	38	.96061	33.24	72	.89298	68.49
5	.99274	4.48	39	.95920	34.32	73	.89048	69.50
6	.99150	5.39	40	.95778	35.38	74	.88792	70.52
7	.99033	6.31	41	.95631	36.43	75	.88534	71.55
8	.98917	7.24	42	.95482	37.47	76	.88273	72.58
9	.98801	8.17	43	.95327	38.53	77	.88010	73.61
10	.98685	9.10	44	.95169	39.58	78	.87747	74.63
11	.98586	9.90	45	.95008	40.61	79	.87477	75.66
12	.98488	10.78	46	.94842	41.64	80	.87206	76.68
13	.98390	11.66	47	.94673	42.66	81	.86931	77.72
14	.98292	12.55	48	.94494	43.72	82	.86650	78.75
15	.98202	13.36	49	.94312	44.78	83	.86370	79.77
16	.98116	14.15	50	.94129	45.82	84	.86080	80.81
17	.98029	14.97	51	.93945	46.85	85	.85785	81.85
18	.97943	15.81	52	.93754	47.88	86	.85490	82.89
19	.97863	16.58	53	.93560	48.91	87	.85181	83.96
20	.97786	17.32	54	.93360	49.96	88	.84869	85.02
21	.97708	18.08	55	.93156	51.02	89	.84555	86.08
22	.97630	18.84	56	.92951	52.04	90	.84226	87.14
23	.97544	19.69	57	.92742	53.07	91	.83887	88.22
24	.97458	20.53	58	.92531	54.10	92	.83548	89.28
25	.97372	21.37	59	.92318	55.12	93	.83191	90.35
26	.97287	22.20	60	.92099	56.16	94	.82827	91.42
27	.97203	23.02	61	.91880	57.19	95	.82440	92.56
28	.97118	23.85	62	.91660	58.21	96	.82033	93.69
29	.97028	24.73	63	.91436	59.23	97	.81617	94.77
30	.96937	25.59	64	.91210	60.24	98	.81199	95.82
31	.96844	26.47	65	.90984	61.25	99	.80757	96.89
32	.96742	27.42	66	.90755	62.27	100	.80302	97.96
33	.96639	28.37	67	.90525	63.28			
				Temperature 45°.				
0	.99974	—0.45	34	.96394	30.52	68	.90070	65.25
1	.99833	+0.54	35	.96275	31.52	69	.89829	66.27
2	.99693	1.53	36	.96154	32.50	70	.89581	67.31
3	.99552	2.52	37	.96028	33.50	71	.89333	68.34
4	.99411	3.51	38	.95902	34.45	72	.89082	69.37
5	.99271	4.50	39	.95759	35.52	73	.88832	70.36
6	.99146	5.42	40	.95616	36.53	74	.88576	71.38
7	.99027	6.35	41	.95465	37.59	75	.88317	72.41
8	.98908	7.31	42	.95313	38.62	76	.88057	73.43
9	.98789	8.27	43	.95155	39.67	77	.87792	74.46
10	.98671	9.22	44	.94994	40.70	78	.87528	75.47
11	.98568	10.05	45	.94829	41.72	79	.87256	76.50
12	.98468	10.96	46	.94661	42.73	80	.86983	77.52
13	.98367	11.87	47	.94489	43.75	81	.86707	78.54
14	.98266	12.78	48	.94308	44.80	82	.86425	79.57
15	.98171	13.65	49	.94125	45.85	83	.86143	80.58
16	.98080	14.49	50	.93940	46.88	84	.85854	81.61
17	.97989	15.36	51	.93753	47.88	85	.85559	82.64
18	.97898	16.24	52	.93560	48.91	86	.85265	83.67
19	.97813	17.06	53	.93363	49.95	87	.84957	84.72
20	.97729	17.87	54	.93162	50.99	88	.84644	85.78
21	.97645	18.70	55	.92957	52.01	89	.84329	86.81
22	.97561	19.52	56	.92751	53.02	90	.84000	87.86
23	.97471	20.40	57	.92540	54.06	91	.83661	88.93
24	.97380	21.29	58	.92328	55.08	92	.83322	89.96
25	.97289	22.19	59	.92113	56.10	93	.82964	91.02
26	.97198	23.07	60	.91894	57.13	94	.82599	92.10
27	.97108	23.95	61	.91674	58.14	95	.82214	93.21
28	.97017	24.83	62	.91453	59.15	96	.81807	94.28
29	.96921	25.75	63	.91228	60.16	97	.81391	95.34
30	.96823	26.66	64	.91002	61.17	98	.80974	96.37
31	.96725	27.58	65	.90773	62.19	99	.80532	97.42
32	.96617	28.56	66	.90542	63.21	100	.80079	98.47
33	.96508	29.53	67	.90310	64.22			

Table IV.—Continued.

Temperature 50°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99962	—0.36	34	.96256	31.67	68	.89854	66.17
1	.99821	+0.63	35	.96131	32.68	69	.89613	67.18
2	.99680	1.62	36	.96006	33.67	70	.89364	68.21
3	.99539	2.61	37	.95873	34.67	71	.89114	69.24
4	.99398	3.60	38	.95741	35.65	72	.88864	70.24
5	.99257	4.60	39	.95596	36.67	73	.88613	71.24
6	.99130	5.54	40	.95449	37.70	74	.88356	72 25
7	.99010	6.50	41	.95295	38.74	75	.88097	73.27
8	.98889	7.46	42	.95140	39.77	76	.87836	74 29
9	.98769	8.43	43	.94979	40.80	77	.87571	75.30
10	.98648	9.40	44	.94816	41.80	78	.87306.	76.31
11	.98543	10.28	45	.94648	42.81	79	.87034	77.33
12	.98438	11.23	46	.94476	43.83	80	.86760	78 35
13	.98334	12.17	47	.94302	44.84	81	.86482	79.36
14	.98230	13.11	48	.94119	45.88	82	.86200	80.38
15	.98131	14.01	49	.93934	46.91	83	.85917	81.39
16	.98036	14.91	50	.93747	47.92	84	.85628	82.40
17	.97941	15.82	51	.93558	48.92	85	.85333	83.43
18	.97846	16.74	52	.93362	49.95	86	.85039	84.44
19	.97754	17.63	53	.93164	50.98	87	.84731	85.48
20	.97664	18.51	54	.92962	51.98	88	.84416	86.53
21	.97575	19.38	55	.92756	53.00	89	.84101	87.54
22	.97484	20.28	56	.92547.	54 02	90	.83771	88 58
23	.97389	21.21	57	.92337	55.03	91	.83432	89.63
24	.97294	22.13	58	.92123	56.05	92	.83093	90.64
25	.97199	23.06	59	.91908	57.06	93	.82735	91.70
26	.97102	24.01	60	.91687	58.08	94	.82369	92.77
27	.97006	24.94	61	.91466	59.09	95	.81986	93.82
28	.96910	25.85	62	.91243	60.09	96	.81578	94.87
29	.96809	26.79	63	.91017	61.10	97	.81164	95.91
30	.96706	27.76	64	.90790	62.11	98	.80746	96.92
31	.96602	28.70	65	.90561	63.12	99	.80306	97.95
32	.96488	29.70	66	.90329	64.13	100	.79853	98.98
33	.96375	30.69	67	.90095	65.15			

Temperature 55°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99941	—0.22	34	.96111	32.85	68	.89636	67.08
1	.99799	+0 78	35	.95982	33.85	69	.89395	68.08
2	.99658	1.77	36	.95852	34.83	70	.89145	69.12
3	.99517	2.77	37	.95714	35.85	71	.88895	70.11
4	.99375	3.77	38	.95576	36.81	72	.88643	71.12
5	.99234	4.76	39	.95428	37.85	73	.88391	72.12
6	.99106	5.73	40	.95279	38.85	74	.88134	73.13
7	.98984	6.70	41	.95122	39.89	75	.87874	74.14
8	.98861	7.69	42	.94964	40 89	76	.87612	75.15
9	.98739	8.67	43	.94799	41.91	77	.87347	76.15
10	.98616	9.67	44	.94633	42.90	78	.87081	77.15
11	.98507	10.60	45	.94462	43.91	79	.86808	78.17
12	.98401	11.56	46	.94288	44.92	80	.86533	79.17
13	.98293	12.54	47	.94111	45 93	81	.86255	80.18
14	.98186	13.51	48	.93926	46.96	82	.85973	81.19
15	.98084	14.45	49	.93740	47.95	83	.85689	82.19
16	.97985	15.40	50	·93551	48 96	84	.85400	83.20
17	.97885	16.36	51	.93361	49.96	85	.85105	84.22
18	.97786	17.32	52	.93162	50.99	86	.84811	85.21
19	.97689	18.26	53	.92962	51 99	87	.84502	86.25
20	.97593	19.21	54	.92758	52.99	88	.84187	87.26
21	.97497	20.15	55	.92552	54.00	89	·83872	88.26
22	.97401	21.09	56	.92342	55.01	90	.83542	89.30
23	.97302	22.06	57	.92130	56.02	91	.83203	90.31
24	.97203	23.02	58	.91915	57.03	92	.82864	91 31
25	.97103	24.00	59	.91698	58.03	93	.82506	92.37
26	.97002	24.98	60	.91477	59.04	94	.82141	93.40
27	.96900	25.94	61	.91254	60.04	95	.81758	94.41
28	.96799	26.89	62	.91030	61.04	96	.81345	95.44
29	.96691	27.90	63	.90804	62.05	97	.80936	96.45
30	.96582	28.88	64	.90577	63.05	98	.80518	97.46
31	.96472	29.84	65	.90347	64.06	99	.80077	98.47
32	.96354	30.87	66	.90112	65.08	100	.79625	99.48
33	.96235	31.84	67	.89877	66.07			

TABLE IV.—Continued.

Temperature 60°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99910	0.00	34	.95963	34.00	68	.89415	68.00
1	.99768	1.00	35	.95829	35.00	69	.89174	69.00
2	.99626	2 00	36	.95693	36.00	70	.88923	70.00
3	.99484	3 00	37	.95549	37.00	71	.88673	71.00
4	.99342	4.00	38	.95406	38.00	72	.88420	72.00
5	.99200	5.00	39	.95256	39.00	73	.88168	73.00
6	.99071	6.00	40	.95106	40.00	74	.87911	74.00
7	.98947	7.00	41	.94946	41.00	75	.87651	75.00
8	.98822	8.00	42	.94784	42.00	76	.87388	76.00
9	.98698	9.00	43	.94616	43.00	77	.87122	77.00
10	.98574	10 00	44	.94447	44.00	78	.86855	78 00
11	.98463	11.00	45	.94274	45.00	79	.86581	79 00
12	.98353	12.00	46	.94098	46.00	80	.86306	80.00
13	.98242	13.00	47	.93918	47.00	81	.86027	81.00
14	.98132	14.00	48	.93731	48 00	82	.85743	82.00
15	.98026	15 00	49	.93543	49.00	83	.85458	83.00
16	.97923	16.00	50	.93353	50.00	84	.85168	84.00
17	.97819	17.00	51	.93161	51.00	85	.84874	85 00
18	.97716	18.00	52	.92959	52.00	86	.84580	86 00
19	.97614	19.00	53	.92756	53.00	87	.84271	87.00
20	.97512	20.00	54	.92552	54.00	88	.83955	88 00
21	.97410	21.00	55	.92344	55.00	89	.83640	89.00
22	.97308	22.00	56	.92134	56.00	90	.83310	90.00
23	.97205	23.00	57	.91921	57.00	91	.82971	91.00
24	.97103	24.00	58	.91705	58.00	92	.82632	92 00
25	.97000	25.00	59	.91487	59.00	93	.82274	93.00
26	.96894	26.00	60	.91264	60.00	94	.81907	94.00
27	.96787	27.00	61	.91040	61 00	95	.81525	95.00
28	.96680	28.00	62	.90815	62.00	96	.81117	96.00
29	.96568	29.00	63	.90589	63.00	97	.80703	97.00
30	.96454	30.00	64	.90360	64.00	98	.80285	98.00
31	.96339	31.00	65	.90130	65.00	99	.79846	99.00
32	.96215	32.00	66	.89894	66.00	100	.79390	100.00
33	.96092	33.00	67	.89656	67.00			

Temperature 65°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99869	0.29	34	.95810	35.14	68	.89191	68.93
1	.99727	1.29	35	.95672	36.15	69	.88950	69.89
2	.99584	2.30	36	.95531	37.13	70	.88699	70.90
3	.99441	3.30	37	.95382	38.16	71	.88448	71.89
4	.99299	4.30	38	.95233	39.15	72	.88195	72.89
5	.99156	5.34	39	.95081	40.16	73	.87942	73.88
6	.99026	6.36	40	.94929	41.10	74	.87685	74.87
7	.98899	7.38	41	.94766	42.11	75	.87424	75.86
8	.98774	8.39	42	.94600	43.10	76	.87161	76.85
9	.98648	9.40	43	.94430	44.10	77	.86894	77.85
10	.98522	10.47	44	.94258	45.09	78	.86628	78.83
11	.98408	11.50	45	.94083	46 08	79	.86352	79.83
12	.98296	12 51	46	.93904	47.07	80	.86075	80.83
13	.98182	13.55	47	.93722	48.05	81	.85796	81.81
14	.98069	14.59	48	.93533	49.05	82	.85512	82.81
15	.97959	15.65	49	.93343	50.05	83	.85226	83.80
16	.97852	16.68	50	.93141	51.05	84	.84936	84.79
17	.97745	17.72	51	.92958	52 00	85	.84641	85.79
18	.97638	18.76	52	.92754	53.01	86	.84347	86.75
19	.97530	19.82	53	.92649	54.01	87	.84037	87.74
20	.97422	20.88	54	.92343	55.00	88	.83722	88.74
21	.97315	21.93	55	.92134	56.00	89	.83406	89.71
22	.97207	22 98	56	.91923	56.99	90	.83076	90 69
23	.97101	24.02	57	.91709	57.98	91	.82737	91.69
24	.96996	25 04	58	.91492	58.98	92	.82398	92 69
25	.96890	26.04	59	.91273	59.96	93	.82040	93.67
26	.96779	27.07	60	.91050	60.96	94	.81675	94.62
27	.96668	28.11	61	.90824	61 96	95	.81292	95 59
28	.96556	29.11	62	.90597	62.96	96	.80884	96.58
29	.96439	30.13	63	.90371	63.95	97	.80470	97.56
30	.96320	31.15	64	.90142	64.95	98	.80053	98 53
31	.96200	32.12	65	.89911	65.93	99	.79613	99.51
32	.96072	33.16	66	.89673	66.93	100	.79161	100.49
33	.95944	34.14	67	.89433	67.93			

TABLE IV.—Continued.

Temperature 70°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99820	0.63	34	.95653	36.28	68	.88965	69.83
1	.99677	1.64	35	.95511	37.27	69	.88722	70.80
2	.99533	2.65	36	.95366	38.27	70	.88471	71.80
3	.99390	3 66	37	.95211	39 30	71	.88220	72.79
4	.99247	4.67	38	.95056	40.31	72	.87966	73 79
5	.99104	5.74	39	.94903	41.27	73	.87713	74.76
6	.98972	6.80	40	.94749	42.21	74	.87455	75.75
7	.98844	7.82	41	.94583	43.20	75	.87194	76.73
8	.98717	8.85	42	.94415	44.19	76	.86931	77.72
9	.98589	9.89	43	.94240	45.19	77	.86663	78.70
10	.98461	11.02	44	.94065	46.18	78	.86396	79.67
11	.98345	12.07	45	.93889	47.16	79	.86120	80.67
12	.98229	13.12	46	.93708	48.12	80	.85843	81.65
13	.98113	14.18	47	.93523	49 11	81	.85564	82.63
14	.97997	15.28	48	.93333	50.10	82	.85280	83.61
15	.97885	16.37	49	.93141	51.10	83	.84994	84.59
16	.97774	17.44	50	.92947	52.06	84	.84703	85.58
17	.97664	18.51	51	.92752	53.02	85	.84408	86.56
18	.97553	19 60	52	.92545	54.03	86	.84113	87.50
19	.97440	20.71	53	.92340	55.02	87	.83803	88.48
20	.97326	21.82	54	.92131	56.01	88	.83488	89.46
21	.97212	22.93	55	.91921	57.00	89	.83172	90.41
22	.97099	24.04	56	.91709	57.98	90	.82841	91.38
23	.96991	25.09	57	.91494	58.97	91	.82502	92.38
24	.96883	26.10	58	.91276	59.95	92	.82163	93.34
25	.96774	27.12	59	.91056	60.93	93	.81805	94.29
26	.96659	28.19	60	.90832	61.92	94	.81438	95.22
27	.96543	29.22	61	.90604	62.93	95	.81056	96.17
28	.96427	30.23	62	.90376	63.93	96	.80650	97.15
29	.96305	31 27	63	.90150	64.91	97	.80234	98.11
30	.96181	32.28	64	.89921	65.89	98	.79818	99.06
31	.96057	33.27	65	.89689	66.86	99	.79378	100.05
32	.95924	34.29	66	.89450	67.85	100	.78927	100.99
33	.95791	35.28	67	.89208	68.86			

Temperature 75°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99760	1.06	34	.95492	37.40	68	.88736	70.75
1	.99615	2.08	35	.95345	38.41	69	.88493	71.71
2	.99472	3 08	36	.95196	39.40	70	.88241	72.71
3	.99328	4.10	37	.95036	40.44	71	.87990	73.69
4	.99184	5.12	38	.94876	41.43	72	.87736	74 67
5	.99040	6.25	39	.94721	42 38	73	.87482	75.64
6	.98907	7.32	40	.94566	43.30	74	.87223	76.62
7	.98777	8.36	41	.94397	44.29	75	.86962	77.60
8	.98649	9.40	42	.94225	45.28	76	.86698	78.57
9	.98519	10.50	43	.94047	46.28	77	.86431	79.55
10	.98391	11.65	44	.93869	47.26	78	.86163	80 51
11	.98271	12.74	45	.93691	48.21	79	.85886	81.50
12	.98153	13 81	46	.93508	49.18	80	.85610	82.47
13	.98034	14.93	47	.93321	50.17	81	.85330	83.44
14	.97915	16.08	48	.93130	51 15	82	.85045	84.42
15	.97800	17.18	49	.92935	52.12	83	.84759	85 39
16	.97686	18.29	50	.92746	53.08	84	.84468	86.36
17	.97572	19.41	51	.92544	54.04	85	.84172	87.31
18	.97458	20 53	52	.92335	55.04	86	.83876	88.25
19	.97340	21.69	53	.92127	56.03	87	.83566	89 22
20	.97220	22 85	54	.91917	57.02	88	.83251	90.17
21	.97100	24.03	55	.91704	58.00	89	.82935	91.11
22	.96981	25 18	56	.91492	58.98	90	.82605	92.08
23	.96872	26 21	57	.91277	59 94	91	.82265	93.08
24	.96762	27.23	58	.91059	60.91	92	.81926	93.97
25	.96652	28.25	59	.90837	61.90	93	.81567	94 90
26	.96533	29 31	60	.90611	62.90	94	.81201	95.81
27	.96413	30 36	61	.90381	63 91	95	.80818	96.75
28	.96293	31.37	62	.90152	64.90	96	.80413	97 70
29	.96166	32 40	63	.89926	65 86	97	.79997	98 65
30	.96038	33.42	64	.89696	66.83	98	.79580	99.58
31	.95910	34.40	65	.89464	67.80	99	.79141	100.53
32	.95773	35.41	66	.89224	68.79	100	.78690	101.48
33	.95634	36.41	67	.88980	69.77			

TABLE IV.—Continued.

Temperature 80°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99692	1.53	34	.95328	38.52	68	.88505	71.66
1	.99547	2.50	35	.95177	39.53	69	.88261	72.63
2	.99402	3.58	36	.95022	40.53	70	.88009	73.62
3	.99257	4.60	37	.94857	41.55	71	.87758	74.59
4	.99112	5.68	38	.94692	42.55	72	.87504	75.56
5	.98967	6.84	39	.94536	43.47	73	.87248	76.53
6	.98831	7.93	40	.94379	44.39	74	.86989	77.50
7	.98701	8.98	41	.94207	45.38	75	.86727	78.47
8	.98571	10.03	42	.94032	46.37	76	.86464	79.43
9	.98440	11.21	43	.93850	47.36	77	.86195	80.40
10	.98310	12.39	44	.93669	48.33	78	.85927	81.35
11	.98188	13.49	45	.93490	49.28	79	.85650	82.33
12	.98067	14.61	46	.93305	50.25	80	.85373	83.29
13	.97945	15.79	47	.93116	51.22	81	.85094	84.25
14	.97824	16.95	48	.92923	52.18	82	.84809	85.22
15	.97706	18.10	49	.92727	53.14	83	.84524	86.18
16	.97589	19.25	50	.92530	54.11	84	.84233	87.12
17	.97472	20.39	51	.92333	55.05	85	.83936	88.06
18	.97355	21.54	52	.92121	56.06	86	.83639	89.00
19	.97232	22.74	53	.91912	57.04	87	.83327	89.95
20	.97106	23.97	54	.91699	58.03	88	.83012	90.88
21	.96980	25.19	55	.91485	59.01	89	.82696	91.81
22	.96856	26.35	56	.91272	59.96	90	.82365	92.78
23	.96745	27.39	57	.91056	60.93	91	.82025	93.71
24	.96633	28.42	58	.90836	61.91	92	.81686	94.59
25	.96522	29.40	59	.90614	62.89	93	.81327	95.50
26	.96400	30.47	60	.90388	63.87	94	.80962	96.40
27	.96276	31.51	61	.90157	64.88	95	.80579	97.31
28	.96151	32.52	62	.89926	65.86	96	.80173	98.25
29	.96021	33.55	63	.89700	66.82	97	.79759	99.19
30	.95890	34.54	64	.89470	67.77	98	.79340	100.11
31	.95758	35.52	65	.89238	68.73	99	.78902	101.04
32	.95616	36.53	66	.88996	69.71	100	.78452	101.97
33	.95474	37.52	67	.88750	70.69			

Temperature 85°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99613	2.09	34	.95157	39.66	68	.88271	72.59
1	.99467	3.12	35	.95002	40.65	69	.88025	73.56
2	.99321	4.15	36	.94844	41.63	70	.87774	74.53
3	.99175	5.19	37	.94675	42.65	71	.87523	75.49
4	.99029	6.34	38	.94505	43.66	72	.87268	76.45
5	.98883	7.51	39	.94347	44.58	73	.87013	77.41
6	.98748	8.60	40	.94189	45.48	74	.86754	78.37
7	.98616	9.67	41	.94014	46.47	75	.86492	79.32
8	.98484	10.81	42	.93836	47.44	76	.86228	80.28
9	.98352	12.01	43	.93650	48.43	77	.85958	81.24
10	.98221	13.19	44	.93466	49.41	78	.85690	82.19
11	.98097	14.33	45	.93287	50.34	79	.85413	83.16
12	.97973	15.51	46	.93100	51.30	80	.85134	84.12
13	.97849	16.71	47	.92908	52.25	81	.84855	85.07
14	.97724	17.92	48	.92713	53.21	82	.84571	86.03
15	.97603	19.11	49	.92517	54.17	83	.84287	86.95
16	.97483	20.28	50	.92318	55.12	84	.83995	87.87
17	.97364	21.45	51	.92119	56.07	85	.83696	88.82
18	.97244	22.62	52	.91905	57.07	86	.83398	89.73
19	.97116	23.87	53	.91694	58.05	87	.83087	90.66
20	.96984	25.15	54	.91478	59.04	88	.82772	91.59
21	.96852	26.39	55	.91262	60.01	89	.82456	92.52
22	.96723	27.60	56	.91048	60.96	90	.82123	93.45
23	.96611	28.62	57	.90834	61.92	91	.81785	94.34
24	.96499	29.61	58	.90614	62.89	92	.81444	95.21
25	.96386	30.59	59	.90390	63.87	93	.81085	96.10
26	.96260	31.64	60	.90162	64.86	94	.80718	96.98
27	.96132	32.67	61	.89930	65.85	95	.80336	97.88
28	.96004	33.68	62	.89697	66.83	96	.79930	98.81
29	.95870	34.69	63	.89471	67.77	97	.79515	99.73
30	.95736	35.68	64	.89242	68.72	98	.79100	100.62
31	.95600	36.65	65	.89009	69.66	99	.78661	101.54
32	.95454	37.66	66	.88766	70.63	100	.78210	102.45
33	.95308	38.65	67	.88518	71.61			

Table IV.—Continued.

Temperature 90°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99525	2.78	34	.94983	40.77	68	.88034	73.52
1	.99377	3.75	35	.94824	41.75	69	.87787	74.48
2	.99231	4.79	36	.94662	42 73	70	.87536	75.44
3	.99084	5.90	37	.94488	43.76	71	.87286	76.38
4	.98937	7.08	38	.94314	44 78	72	.87030	77 34
5	.98790	8.26	39	.94155	45.68	73	.86775	78 29
6	.98653	9 37	40	.93996	46.57	74	.86514	79.24
7	.98519	10.50	41	.93818	47.53	75	.86252	80.19
8	.98387	11.69	42	.93636	48.51	76	.85987	81.14
9	.98254	12.89	43	.93447	49.51	77	.85718	82.09
10	.98121	14.10	44	.93260	50.49	78	.85449	83 03
11	.97995	15.30	45	.93080	51.40	79	.85172	83.99
12	.97868	16.53	46	.92891	52.33	80	.84894	84.93
13	.97742	17 75	47	.92697	53.29	81	.84614	85.88
14	.97616	18.98	48	.92501	54 25	82	.84332	86.80
15	.97492	20.20	49	.92303	55.20	83	.84049	87.70
16	.97370	21.39	50	.92103	56.15	84	.83755	88.63
17	.97247	22.59	51	.91902	57.09	85	.83455	89.56
18	.97124	23.79	52	.91685	58.09	86	.83155	90.46
19	.96991	25.09	53	.91473	59.06	87	.82844	91.37
20	.96853	26.38	54	.91256	60.04	88	.82529	92.30
21	.96716	27.66	55	.91037	61.01	89	.82213	93.21
22	.96582	28.88	56	.90822	61.97	90	.81882	94.09
23	.96469	29.87	57	.90609	62 91	91	.81542	94 96
24	.96356	30.85	58	.90388	63.88	92	.81200	95.82
25	.96243	31.78	59	.90162	64.86	93	.80841	96.69
26	.96114	32.82	60	.89934	65.83	94	.80475	97.56
27	.95983	33.84	61	.89700	66.82	95	.80093	98.44
28	.95851	34.84	62	.89466	67.79	96	.79686	99 35
29	.95714	35.85	63	.89240	68.73	97	.79272	100.25
30	.95577	36.81	64	.89010	69.65	98	.78857	101.13
31	.95438	37.78	65	.88777	70 58	99	.78418	102 03
32	.95288	38 78	66	.88532	71.56	100	.77967	102.94
33	.95138	39.78	67	.88282	72.55			

Temperature 95°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99428	3.39	34	.94805	41.87	68	.87796	74 44
1	.99280	4.44	35	.94641	42.85	69	.87545	75.40
2	.99132	5.53	36	.94475	43.83	70	.87295	76.35
3	.98983	6.71	37	.94298	44.86	71	.87046	77.28
4	.98835	7.90	38	.94119	45 88	72	.86790	78.24
5	.98687	9.09	39	.93959	46.77	73	.86534	79.17
6	.98548	10.23	40	.93800	47.63	74	.86274	80.12
7	.98413	11.45	41	.93618	48.60	75	.86011	81 06
8	.98279	12.67	42	.93433	49.58	76	.85746	81.99
9	.98145	13 89	43	.93240	50.59	77	.85476	82 94
10	.98011	15.14	44	.93050	51.55	78	.85206	83.87
11	.97883	16.38	45	.92870	52.44	79	.84929	84.81
12	.97754	17.63	46	.92679	53.38	80	.84651	85.76
13	.97625	18 89	47	.92482	54.34	81	.84372	86.67
14	.97497	20.15	48	.92285	55.28	82	.84090	87.57
15	.97371	21.38	49	.92086	56.23	83	.83808	88.47
16	.97246	22.60	50	.91884	57.17	84	.83514	89.38
17	.97121	23.82	51	.91682	58.11	85	.83213	90.29
18	.96996	25.04	52	.91463	59.11	86	.82911	91.18
19	.96858	26 34	53	.91250	60.06	87	.82599	92 09
20	.96716	27 66	54	.91030	61.04	88	.82284	93.02
21	.96573	28.96	55	.90809	62.03	89	.81968	93.86
22	.96434	30 17	56	.90593	62.98	90	.81636	94 72
23	.96320	31.16	57	.90381	63.91	91	.81296	95.58
24	.96207	32.07	58	.90160	64.87	92	.80955	96 41
25	.96094	32.98	59	.89933	65.83	93	.80595	97.27
26	.95962	34.01	60	.89703	66.80	94	.80229	98.13
27	.95828	35.01	61	.89467	67.78	95	.79846	99.00
28	.95693	36.00	62	.89231	68.76	96	.79441	99 89
29	.95553	36.97	63	.89006	69.67	97	.79027	100.77
30	.95413	37.95	64	.88777	70.58	98	.78611	101 64
31	.95272	38.89	65	.88543	71 51	99	.78173	102.53
32	.95118	39.92	66	.88296	72 49	100	.77723	103.42
33	.94964	40.89	67	.88046	73.47			

TABLE IV.—Continued.

Temperature 100°.

True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.	True per cent.	Apparent specific gravity.	Apparent per cent.
0	.99321	4.15	34	.94622	42.96	68	.87553	75.37
1	.99172	5.22	35	.94455	43.95	69	.87301	76.33
2	.99022	6.40	36	.94285	44.94	70	.87053	77.26
3	.98872	7.60	37	.94103	45.97	71	.86804	78.19
4	.98723	8 80	38	.93920	46.99	72	.86549	79.12
5	.98574	10.00	39	.93760	47.85	73	.86292	80 05
6	.98434	11.26	40	.93600	48.70	74	.86031	80.99
7	.98299	12.49	41	.93415	49.67	75	.85768	81.91
8	.98163	13.72	42	.93227	50.66	76	.85502	82 85
9	.98028	14 98	43	.93030	51.65	77	.85231	83.78
10	.97892	16.30	44	.92837	52.60	78	.84962	84.70
11	.97761	17.56	45	.92657	53 49	79	.84685	85.64
12	.97630	18.84	46	.92464	54.42	80	.84407	86.56
13	.97499	20.13	47	.92266	55.38	81	.84128	87.45
14	.97369	21 40	48	.92067	56.31	82	.83847	88.34
15	.97241	22.65	49	.91866	57.26	83	.83567	89.22
16	.97113	23.90	50	.91663	58.19	84	.83272	90.11
17	.96987	25.12	51	.91460	59 12	85	.82969	91.01
18	.96860	26.32	52	.91239	60 11	86	.82666	91.90
19	.96718	27.64	53	.91024	61.07	87	.82352	92.82
20	.96569	28.99	54	.90802	62.06	88	.82037	93.68
21	.96421	30.29	55	.90578	63.05	89	.81721	94.50
22	.96277	31.50	56	.90363	63.99	90	.81390	95.34
23	.96165	32.41	57	.90150	64.91	91	.81049	96.19
24	.96052	33.31	58	.89938	65 81	92	.80708	97.01
25	.95938	34.19	59	.89700	66.82	93	.80347	97.85
26	.95804	35.18	60	.89469	67.78	94	.79980	98.69
27	.95666	36 19	61	.89232	68.76	95	.79597	99.55
28	.95528	37.15	62	.88994	69.72	96	.79191	100.42
29	.95387	38.13	63	.88770	70.61	97	.78778	101.29
30	.95244	39.08	64	.88541	71.52	98	.78362	102 15
31	.95100	40.04	65	.88306	72.45	99	.77926	103.02
32	.94943	41.02	66	.88058	73.43	100	.77475	103.90
33	.94785	41.99	67	.87806	74.40			

SUPPLEMENT TO TABLE IV.—*Giving apparent specific gravities and apparent per cent. for temperatures between 0° and 25°, as derived from the supplement to Table III.*

Temperature 0°.

True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.
30	18.7	.9764	48	34.2	.9593	65	53.7	.9261	83	73.2	.8812
31	18.9	.9762	49	35.4	.9577	66	54.8	.9239	84	74.3	.8783
32	19.2	.9759				67	55.9	.9216			
33	19.7	.9754	50	36.6	.9561	68	57.0	.9193	85	75.4	.8754
34	20.2	.9749	51	37.8	.9544	69	58.0	.9170	86	76 6	.8724
			52	39.0	.9526				87	77.7	.8694
35	20.9	.9742	53	40.2	.9507	70	59.1	.9146	88	78.8	.8663
36	21.5	.9736	54	41.3	.9489	71	60.2	.9122	89	80.0	.8631
37	22.3	.9728				72	61.3	.9098			
38	23.1	.9720	55	42.5	.9470	73	62.4	.9073	90	81.1	.8599
39	23.9	.9711	56	43.7	.9450	74	63.4	.9049	91	82.3	.8566
			57	44 9	.9429				92	83.4	.8533
40	24.9	.9701	58	46 0	.9409	75	64.5	.9024	93	84.6	.8499
41	25.8	.9692	59	47.2	.9388	76	65 6	.8999	94	85.8	.8464
42	26.9	.9680				77	66.7	.8973			
43	28.1	.9667	60	48.3	.9368	78	67 8	.8947	95	87.0	.8427
44	29.3	.9653	61	49.4	.9347	79	68.9	.8921	96	88.2	.8388
			62	50.5	.9326				97	89.5	.8347
45	30.6	.9638	63	51.5	.9305	80	69.9	.8894	98	90.8	.8304
46	31.8	.9624	64	52.6	.9283	81	71.0	.8867	99	92.1	.8258
47	33.0	.9609				82	72.1	.8840	100	93.5	.8209

SUPPLEMENT TO TABLE IV.—Continued.

Temperature 5°.

True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.
30	19.5	.9756	48	35.6	.9575	65	54.7	.9240	83	74.0	.8791
31	19.7	.9754	49	36.7	.9559	66	55.8	.9218	84	75.1	.8762
32	20.1	.9750	50	37.9	.9542	67	56.9	.9195	85	76.2	.8733
33	20.7	.9744	51	39.0	.9525	68	57.9	.9172	86	77.3	.8703
34	21.3	.9738	52	40.2	.9507	69	59.0	.9149	87	78.5	.8673
35	22.0	.9731	53	41.4	.9488	70	60.0	.9126	88	79.6	.8642
36	22.7	.9724	54	42.6	.9469	71	61.1	.9102	89	80.7	.8610
37	23.4	.9716	55	43.7	.9450	72	62.2	.9078	90	81.9	.8577
38	24.3	.9707	56	44.8	.9430	73	63.3	.9053	91	83.1	.8544
39	25.2	.9698	57	46.0	.9409	74	64.3	.9028	92	84.2	.8511
40	26.2	.9687	58	47.1	.9389	75	65.4	.9003	93	85.4	.8477
41	27.3	.9676	59	48.3	.9368	76	66.5	.8978	94	86.5	.8442
42	28.4	.9664	60	49.3	.9348	77	67.6	.8952	95	87.7	.8405
43	29.6	.9650	61	50.4	.9327	78	68.6	.8926	96	88.9	.8366
44	30.8	.9636	62	51.5	.9306	79	69.7	.8900	97	90.2	.8325
45	32.0	.9621	63	52.6	.9284	80	70.8	.8873	98	91.5	.8281
46	33.2	.9606	64	53.7	.9262	81	71.8	.8846	99	92.8	.8235
47	34.4	.9591				82	72.9	.8819	100	94.1	.8186

Temperature 10°.

True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.
30	20.2	.9749	48	36.8	.9558	65	55.7	.9220	83	74.9	.8769
31	20.6	.9745	49	37.9	.9542	66	56.7	.9198	84	76.0	.8740
32	21.1	9740	50	39.0	.9525	67	57.8	.9175	85	77.1	.8711
33	21.7	.9734	51	40.2	.9507	68	58.8	.9152	86	78.2	.8681
34	22.3	.9727	52	41.3	.9489	69	59.9	.9129	87	79.3	.8651
35	23.1	.9719	53	42.5	.9470	70	61.0	.9105	88	80.4	.8620
36	23.8	.9712	54	43.6	.9451	71	62.0	.9081	89	81.5	.8588
37	24.7	.9703	55	44.7	.9432	72	63.1	.9057	90	82.7	.8555
38	25.6	.9694	56	45.9	.9412	73	64.2	.9032	91	83.8	.8522
39	26.5	.9684	57	47.0	.9391	74	65.3	.9007	92	84.9	.8489
40	27.6	.9672	58	48.1	.9371	75	66.3	.8982	93	86.1	.8455
41	28.6	.9661	59	49.2	.9350	76	67.4	.8957	94	87.2	.8420
42	29.8	.9648	60	50.3	.9329	77	68.4	.8931	95	88.4	.8383
43	31.0	.9634	61	51.4	.9308	78	69.5	.8905	96	89.6	.8344
44	32.1	.9620	62	52.5	.9286	79	70.6	.8878	97	90.8	.8303
45	33.3	.9605	63	53.6	.9264	80	71.6	.8851	98	92.1	.8259
46	34.5	.9590	64	54.6	.9242	81	72.7	.8824	99	93.4	.8213
47	35.7	.9574				82	73.8	.8797	100	94.7	.8164

Temperature 15°.

True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.
30	21.1	.9740	48	38.0	.9540	65	56.6	.9201	83	75.6	.8749
31	21.6	.9735	49	39.2	.9523	66	57.6	.9179	84	76.7	.8720
32	22.1	.9730	50	40.3	.9506	67	58.7	.9156	85	77.8	.8691
33	22.8	.9723	51	41.3	.9489	68	59.7	.9133	86	78.9	.8661
34	23.5	.9715	52	42.4	.9471	69	60.7	.9110	87	80.0	.8630
35	24.4	.9706	53	43.6	.9452	70	61.8	.9086	88	81.1	.8599
36	25.2	.9698	54	44.7	.9433	71	62.9	.9062	89	82.3	.8567
37	26.0	.9689	55	45.8	.9413	72	64.0	.9037	90	83.4	.8534
38	26.9	.9680	56	46.9	.9393	73	65.0	.9012	91	84.5	.8501
39	27.9	.9669	57	48.0	.9372	74	66.1	.8987	92	85.7	.8466
40	29.0	.9657	58	49.1	.9352	75	67.1	.8962	93	86.8	.8432
41	30.0	.9645	59	50.2	.9331	76	68.2	.8937	94	88.0	.8397
42	31.2	.9632	60	51.3	.9310	77	69.3	.8911	95	89.1	.8360
43	32.3	.9618	61	52.3	.9289	78	70.3	.8885	96	90.3	.8321
44	33.6	.9602	62	53.4	.9267	79	71.4	.8858	97	91.5	.8279
45	34.7	.9587	63	54.5	.9245	80	72.4	.8831	98	92.8	.8235
46	35.8	.9572	64	55.5	.9223	81	73.5	.8804	99	94.1	.8189
47	36.9	.9556				82	74.5	.8777	100	95.3	.8140

SUPPLEMENT TO TABLE IV.—Continued.

Temperature 20°.						Temperature 25°.					
True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.	True per cent.	Apparent per cent.	Apparent specific gravity.
30	21.9	0.9732	65	57.6	0.9180	30	22.7	0.9724	65	58.5	0.9160
31	22.5	.9726	66	58.6	.9157	31	23.3	.9717	66	59.5	.9137
32	23.1	.9720	67	59.7	.9134	32	24.0	.9710	67	60.6	.9114
33	23.8	.9712	68	60.7	.9111	33	24.9	.9701	68	61.6	.9091
34	24.7	.9703	69	61.7	.9088	34	25.8	.9692	69	62.6	.9068
35	25.5	.9695	70	62.8	.9064	35	26.6	.9683	70	63.7	.9044
36	26.4	.9685	71	63.8	.9040	36	27.5	.9673	71	64.7	.9020
37	27.2	.9677	72	64.9	.9015	37	28.4	.9664	72	65.8	.8995
38	28.2	.9666	73	66.0	.8990	38	29.4	.9652	73	66.8	.8970
39	29.2	.9654	74	67.0	.8965	39	30.5	.9640	74	67.9	.8944
40	30.3	.9642	75	68.1	.8940	40	31.5	.9628	75	68.9	.8919
41	31.3	.9630	76	69.1	.8914	41	32.5	.9615	76	70.0	.8893
42	32.4	.9616	77	70.2	.8888	42	33.7	.9600	77	71.0	.8867
43	33.6	.9601	78	71.2	.8862	43	34.8	.9585	78	72.0	.8841
44	34.8	.9586	79	72.3	.8835	44	36.0	.9569	79	73.1	.8814
45	35.9	.9571	80	73.3	.8808	45	37.1	.9554	80	74.2	.8787
46	37.0	.9555	81	74.4	.8782	46	38.2	.9538	81	75.2	.8760
47	38.1	.9539	82	75.4	.8755	47	39.2	.9522	82	76.3	.8732
48	39.2	.9523	83	76.5	.8727	48	40.3	.9505	83	77.3	.8704
49	40.3	.9506	84	77.5	.8698	49	41.4	.9488	84	78.4	.8675
50	41.4	.9488	85	78.6	.8669	50	42.5	.9470	85	79.4	.8646
51	42.5	.9470	86	79.7	.8639	51	43.6	.9452	86	80.5	.8617
52	43.6	.9452	87	80.8	.8608	52	44.7	.9433	87	81.6	.8586
53	44.7	.9433	88	81.9	.8577	53	45.8	.9414	88	82.7	.8555
54	45.8	.9413	89	83.0	.8545	54	46.9	.9394	89	83.8	.8523
55	46.9	.9393	90	84.1	.8512	55	48.0	.9374	90	84.9	.8490
56	48.1	.9372	91	85.3	.8479	56	49.1	.9353	91	86.0	.8457
57	49.1	.9352	92	86.4	.8445	57	50.1	.9333	92	87.1	.8423
58	50.2	.9331	93	87.5	.8411	58	51.2	.9312	93	88.2	.8388
59	51.3	.9310	94	88.6	.8376	59	52.2	.9291	94	89.3	.8353
60	52.3	.9289	95	89.8	.8339	60	53.3	.9270	95	90.4	.8316
61	53.4	.9268	96	90.9	.8300	61	54.3	.9249	96	91.6	.8277
62	54.4	.9246	97	92.2	.8258	62	55.4	.9227	97	92.8	.8235
63	55.5	.9224	98	93.4	.8214	63	56.4	.9205	98	94.0	.8191
64	56.5	0.9202	99	94.6	.8168	64	57.4	0.9183	99	95.2	.8145
			100	95.8	0.8119				100	96.4	0.8096

EXPERIMENTS MADE AT THE SURGEON-GENERAL'S OFFICE, UNITED STATES ARMY, IN WASHINGTON CITY.

The apparatus with which experiments were made on the specific gravity of alcohol at temperatures below 32° Fahrenheit, consisted essentially of a glass bulb loaded with mercury and suspended from the arm of a balance, a brass can to contain the liquid under examination, and a small tub in which the can was placed and surrounded by a freezing mixture.

This can or cup was prolonged below into a tube through which passed a rod carrying a screw-shaped stirrer, by means of which rapid currents could be excited in the liquid, and its

uniformity of temperature insured. The rod was turned by a multiplying wheel which could give a rapidity of motion much in excess of what was actually required.

The brass can, which was $7\frac{1}{4}$ inches deep by $3\frac{1}{2}$ in diameter, was immersed in the freezing mixture to about half an inch from its top, and was filled with alcohol to within about one inch of the same level, leaving an empty space above of some ten cubic inches. It was closed by a tightly fitting brass cover, in which were inserted three tubes open at both ends; one large one in the centre through which passed the fine wire by which the plunger was suspended, and one small one on each side. Through one of these smaller tubes an accurate thermometer was inserted, and the other was connected by means of an India-rubber tube with a half-gallon bottle which contained a small quantity of strong sulphuric acid, and served as a reservoir of desiccated air.

One of the main difficulties which presented itself in considering the question of accurate determination of specific gravities at low temperatures was this, that when the spirit was cooled below the dew point of the atmosphere, moisture would begin to condense on its surface so that its composition would be continually changing by the absorption of water, the rapidity of change depending upon the humidity of the air and the amount of it which came into contact with the alcohol.

It was unavoidable that there should be an empty space over the alcohol in the can, and that this space should communicate with the external air; but in order to hinder the freedom of admixture, the communication was made through a tube of some length and capacity; and further, by means of a hand pump, small quantities of air which had been dried in the sulphuric acid bottle were from time to time introduced into the air space of the can. That this device was effective, was ascertained by observing that while moisture was thickly deposited on the outside of the can, sometimes in the form of ice, none could be detected on its inner surface, even where most exposed to the external atmosphere.

During the latter part of the experiments a lining of thick blotting-paper was pasted on the inside of the cover of the can, to act as an absorbent of any moisture that might deposit. This precaution was apparently superfluous as long as the injection of air from the sulphuric-acid bottle was attended to.

The glass bulb used in the experiments weighed in air 54.064 grammes, and when immersed in distilled water at 60°, 1.602. It displaced, therefore, 52.462 grammes of distilled water at 60°, and to this weight the densities as determined were referred.

The general course of experiment was to introduce the alcohol into the can to determine its density at some moderate temperature, and then to fill around it with a mixture of salt and pounded ice and to stir the alcohol frequently until it had reached its lowest temperature, which it did in from one and a half to two hours, when the thermometer ceased to fall and remained stationary for some time; the stirring was then intermitted and the immersed plunger weighed. The temperature then beginning to rise slowly, requiring about three hours to change from zero to 32°, the operation of weighing was repeated from time to time until a series of weighings had been made at temperatures below 32°.

The day's work was then generally finished by removing a part of the ice from the tub and adding enough warm water to raise the temperature to that included in the ordinary tables. A final weighing of the immersed plunger then gave the means of determining whether the spirit had altered its density during the course of the day.

The freezing mixture used in the tub was in all cases broken ice and salt. It was put in until its level was at or a little above the level of the alcohol, and was occasionally stirred up, a thermometer being used to make certain that no great difference of temperature existed between its top and bottom.

The rate of rise of temperature in the freezing mixture was, as has been previously stated, about a degree Fahrenheit in six minutes. While a rapid motion of the stirrer was kept up, the alcohol in the can closely followed this change, and the temperature of the glass bulb could not have lagged behind to any material extent. Upon the cessation of motion a condition of stable temperature would result, lasting until currents of convection caused by the increasing heat of the freezing mixture had been established in the alcohol.

This temporary condition of stability enabled the plunger to be weighed with sufficient accuracy, that is, to within the error which would result from the variation of a twentieth of a degree Fahrenheit.

The balance used was capable of indicating one-fifth of a milligramme, but as the variation of one degree Fahrenheit caused a change of more than two centigrammes in the apparent weight of the plunger, errors of weighing not greater than a milligramme were disregarded.

Date.	Weight of bulb in air.	Thermometer.	Barometer.	Attached thermometer.	Date.	Weight of bulb in distilled water.	Temperature.
	Gram.					Gram.	
April 10,1868.........	54.064	64°	30.11	72	March 5, 1868.......	1.599	59.5
April 20,1868.........	54.064	64	30.19	64	March 5, 1868.......	1.602	60 0
April 30,1868.........	54 064	71.5	29.95	75	March 6, 1868.......	1.611	61.7
March 13, 1868.......	54.065	75	29.95	75	March 6, 1868.......	1.607	60.5
	54.065	70.5	30.00	75	March 6, 1868.......	1.651	69.5
					March 6, 1868.......	1.712	79.0
					March 6, 1868.......	1.794	89.9
					March 6, 1868.......	1.788	89.0
					March 6, 1868.......	1.653	70.0
					March 7, 1868.......	1.575	50.0
					March 7, 1868.......	1.570	39.2
					March 7, 1868.......	1.584	32.0

NOTE.—Mean weight of bulb in air corrected for buoyancy of air = 54.1212 grammes. Mean weight of water displaced by bulb, at temperature 39°.4 Fah., = 52.568 grammes.

60 PER CENT. OF ALCOHOL—APPROXIMATE.

Date.	Weight of bulb in mixture.	Temperature of mixture.	Specific gravity.	Date.	Weight of bulb in mixture.	Temperature of mixture.	Specific gravity.
1868.	Gram.			1868.	Gram.		
April 11...............	6.442	72	0.9070	April 21..............	5.305	20	0.9286
	4.929	1.6	.9358		5.300	20	.9287
	4.917	1	.9360		5.449	27	.9259
	4 908	0.5	.9361		5.556	32	.9239
	6.491	74.5	.9061		5.788	43	.9195
April 14...............	6.428	71.7	.9073		6.365	69	.9085
	4.929	1.7	.9358	April 22..............	6.491	74.8	.9061
	5.000	5.1	.9342	11.00 A.M.....	6.463	73.5	.9066
	6.430	71.9	.9072	11.45..........	5.180	14.9	.9312
April 20...............	6.356	68.7	.9086	11.55..........	5.050	8.2	.9335
	4.913	1.2	.9361	12.05 P.M.....	4.994	5.5	.9345
	4.907	1.0	.9362	12 10..........	4.964	4	.9351
	4.891	0.1	.9365	12.15..........	4.934	2.5	.9357
	4 885	0	.9366	12.20..........	4.922	1.5	.9359
	4.886	0	.9366	12.25..........	4.906	1	.9362
	5.132	12	.9319	1.35..........	4.886	0	.9366
	5.153	13	.9315	2.00..........	5.300	20	.9287
	5.200	15	.9306	2.15..........	5.486	29	.9252
	5.559	32	.9238	2.25..........	5.506	30	.9248
	6.334	67.7	.9091	2.35..........	5 635	36	.9223
April 21...............	6.356	68.7	.9086	2.50..........	5.720	40	.9207
	5.080	10	.9329	3.00..........	5.930	50	.9168
	4.990	5	.9346	3.20..........	6.222	63	.9112
	5.196	15	.9307	3.40..........	6.200	62	.9116
	5.284	19.1	.9290				

55 PER CENT. OF ALCOHOL—APPROXIMATE.

Date.	Weight of bulb in mixture.	Temperature of mixture.	Specific gravity.	Date.	Weight of bulb in mixture.	Temperature of mixture.	Specific gravity.
1868.	*Gram.*			1868.	*Gram.*		
April 23, P. M.	5.951	75	0.9163	April 27, 2 P. M.	4.683	15	0.9404
2.30	5.664	62	.9218	2.30	4.580	10	.9424
April 24, A. M.	5.776	67	.9197	2.45	4.602	11	.9420
11.30	4.372	−0.5	.9464	3.15	4.705	16	.9400
11.45	4.359	−1.3	.9466	April 29, P. M.	5.720	65	.9207
12	4.389	0	.9461	12.45	4.440	3.5	.9451
12.10 P. M.	4.408	+1	.9457	1.15	4.533	8.8	.9433
2.15	4.694	15.3	.9402	2	4.590	11	.9422
2.45	4.787	20	.9384	2.15	4.675	15	.9403
3.45	5.032	32	.9338	2.40	4.730	18	.9392
4	5.904	72.9	.9172	3.30	5.413	51	.9266
April 25, A. M.	5.763	66.6	.9199	April 30, A. M.	5.861	71.8	.9181
11.30	4.426	2	.9454	1 P. M	4.505	7	.9438
12	4.403	1	.9458	1.45	4.564	10	.9427
12.20 P.M.	4.388	0	.9461	2¼	4.585	11	.9423
2	4.845	23.5	.9374	2.20	4.605	12	.9419
2.30	4.988	30	.9347	2.30	4.623	13	.9416
3	5.665	62	.9218	2.40	4.642	14	.9413
April 27, P. M.	5.885	72.1	.9176	2 50	4.662	15	.9409
1	4.444	3	.9450	3	4.683	16	.9405
1.10	4.461	4	.9447	8.10	4.702	17	.9401
1.30	4.482	5	.9443	3.20	4.721	18	.9397

82 PER CENT. OF ALCOHOL—APPROXIMATE.

March 27	9.481	68.1	0.8511	March 27, 2.10 P.M.	7.887	0	0.8795
	7.881	−0.1	.8796	2.30	7.887	0	.8795
	7.857	−1.1	.8801		9.501	69	.8488
	7.838	−2.2	.8804	March 28, A.M	9.344	62.8	.8518
	7.847	−1.6	.8803	P.M.	8.100	9.8	.8752
	7.850	−1.5	.8803		8.101	10.1	.8752
	7.863	−1	.8801		8.082	9	.8758
	7.862	−1	.8801		8.448	25	.8691
1.15 P.M.	7.900	+1	.8793		9.389	64.8	.8509

40 PER CENT. OF ALCOHOL—APPROXIMATE.

May 20, 2.15 P. M.	4.147	60	0.9507	June 10, 1.55 P. M.	3.236	6	0.9680
May 21, P. M.	4.275	66.9	.9482	2.10	3.253	7	9677
1.40	3.172	1	.9692	2.20	3.267	8	.9674
2.10	3.330	11	.9662	2.35	3.293	10	.9669
2.20	3.340	12	.9660	2.50	3.456	20	.9638
2.35	3.355	13	.9657	3.30	3.663	33	.9599
2.45	3.373	14	.9654	June 11, A.M.	4.313	70	.9475
3	3.389	15	.9651	11.55	3.280	9	.9671
3 15	4.149	60	.9506	12.25 P.M.	3.309	11	.9666
June 9, A. M.	4.435	76	.9452	12.35	3.325	12	.9663
10.50	3.263	7.5	.9675	12.45	3.340	13	.9660
	3.298	10	.9668	12 55	3.355	14	.9657
	3.460	20.5	.9637	1.05	3.367	15	.9655
2 40 P. M.	3.491	22 5	.9631	1.20	3.367	15	.9655
3.15	3.509	23.5	.9628	1.50	3.385	16	.9652
June 10, A.M.	4.386	73.5	.9461	2	3.400	17	.9649
12 M.	3.143	0	.9698	2.10	3.415	18	.9646
12.30 P. M.	3.143	0	.9697	3	3.448	20	.9640
1 P. M.	3.160	1	.9694	3.30	3.639	32	.9603
1.10	3.178	2	.9691	3.50	4.126	60	.9511
1.30	3.206	4	.9686	June 12, 10.30 A.M.	4.124	60	.9511
1.45	3.220	5	.9683				

WASHINGTON, July 21, 1866.

SIR: The committee of the National Academy of Sciences, appointed in pursuance of your request, under date of February 15, to advise the Treasury Department on the best mode of proving and gauging distilled spirits, have the honor to submit the accompanying report, together with an instrument and book of tables, which they recommend to be used in the inspection of spirits. The preparation of the latter has somewhat delayed the presentation of this report.

The conclusions reached, and recommendations submitted, are briefly as follows:—

ON PROVING THE STRENGTH OF SPIRITS.

1. In conformity with the general usage of distillers, rectifiers, and dealers in spirits, the strength of spirituous liquors, in levying duties, should be estimated according to their equivalent of proof spirit, defined to be that alcoholic liquor which contains one-half of its volume of absolute alcohol.

2. Instead of using the terms *above* and *below* proof, the *percentage* of proof spirit contained in liquor should be stated, and the hydrometers should be graduated accordingly. Proof spirits will thus be indicated by 100 on the scale, alcohol by 200, water by 0. The per cents. of alcohol contained in the liquor will be represented by just one-half the numbers indicating the per cents. of proof spirits, and will be identical with those of the "Tralles" scale.

3. The hydrometers should be made of glass, and graduated to indicate true per cents. of proof spirit, when the liquor is at a temperature of 60° Fahr. Of a great variety of patterns submitted, the committee give the preference to that presented by Mr. G. Tagliabue, of New York, who has made the accompanying instrument in accordance with their views.

It consists of five separate hydrometers in series, covering the whole range from water to alcohol, and so arranged that for the inspection of any particular class of liquors, only one of them is required. They are compact, of moderate size, and not easily broken. The scales are very open, and afford great accuracy and facility in reading. Each set is accompanied by a copper case or cup, for containing the liquor, with an attached thermometer.

4. A table is herewith presented to be used in connection with the hydrometers, giving the true per cents. of proof spirit for any indication of the hydrometer at temperatures between 0° and 100° Fahr. This table is so full as to leave no computation for fractions to be made; the required value is at once found by inspection, and in proving a particular lot of spirits

all the entries required will, in general, be found on the same page.

5. The hydrometers should be tested by an officer of the government, and, as no stamp can be placed upon them, should be manufactured with a label on the inside of the bulb, designating them as government standards: those that will not bear the test to be broken. The hydrometers and tables should be issued to inspectors by the Internal Revenue Bureau, either with or without charge for their cost, as may be deemed best.

The committee recommend that the government issue them free of charge, with a certain allowance for breakage, the excess over which should be paid for by the inspector. It is understood that the full set of hydrometers with a cup and thermometer, packed in a neat box, can be supplied at a cost of twenty dollars ($20); single hydrometers to supply breakage at $2 50.

ON GAUGING THE QUANTITY OF SPIRITS.

6. As the volume of a given quantity of spirits varies considerably with the temperature, it is obvious that the duty should be assessed upon the number of gallons it occupies at the average temperature of 60° Fahr. All methods of measuring or gauging the contents of casks being somewhat uncertain, while their weight is readily ascertained, and not variable with the temperature, the committee recommend that, instead of gauging, the quantity of spirits should be estimated by means of their weight. With that view, they submit Table II. of the manual, which gives the number of gallons corresponding to different weight and strength of spirits.

7. As it may not be practicable to introduce at once the system of weighing the casks, and they will continue to be gauged, a column for reducing the volume measure at any temperature to its equivalent at 60° Fahr. is given in Table I., in conjunction with the true per cents. The use of this table should be enjoined.

8. For the information of inspectors and manufacturers, a short table is added to the manual giving the specific gravity for each degree of strength of spirits, and the relative proportions of alcohol and water contained.

All of which is respectfully submitted by

JOSEPH HENRY,
M. C. MEIGS,
J. E. HILGARD.
Committee of the National Academy of Sciences.

HON. HUGH MCCULLOCH,
Secretary of the Treasury.

TREASURY DEPARTMENT,
August 1, 1866.

SIR: I am directed by the Secretary to acknowledge the receipt of the report of the committee of the National Academy of Sciences, appointed in pursuance of my request of February 15, to advise this department on the best mode of proving and gauging distilled spirits. The Secretary further instructs me to return you his thanks for the information and advice contained in the report in question.

Respectfully yours,
WM. E. CHANDLER,
Assistant Secretary.

Professor JOSEPH HENRY,
Smithsonian Institution.

MANUAL FOR INSPECTORS OF SPIRITS.

EXPLANATION OF THE TABLES, AND DIRECTIONS FOR THEIR USE.

TABLE I.—TRUE PER CENT.

Proof spirit is defined by law to be that mixture of alcohol and water which contains one-half of its volume of alcohol; the alcohol when at a temperature of 60° Fahr. being of specific gravity 0.79390, referred to water at its maximum density as unity. Proof spirit has, at 60° Fahr., a specific gravity of 0.93353, 100 parts by volume of the same consisting of 50 parts of absolute alcohol and 53.71 parts of water. The difference of the sum of the parts of the alcohol and water, and the resulting 100 parts of proof spirit, is due to the contraction which takes place when alcohol and water combine.

As the law declares that "the duties on all spirits shall be levied according to their equivalent in proof spirits," the hydrometers furnished to the inspectors are so graduated as to indicate the number of parts by volume of proof spirit equivalent to 100 parts of the liquor *at the standard temperature of 60° Fahr.;* thus they read 0 for water, 100 for proof spirit, and 200 for absolute alcohol.

It is seldom, however, that the liquor is inspected at 60° Fahr.; and as its density varies with the temperature, a correction is necessary for a temperature differing from 60°, the hydrometer giving too low an indication for temperatures below 60°, and one too high for those above. This correction applied

to the indication of the hydrometer, gives the *true per cent.*, or what the reading of the hydrometer would be were the liquor at 60°.

Table I. has been prepared accordingly, and exhibits the true per cents. by volume of proof spirit for such indications of the hydrometer at temperatures between 0° and 100° Fahr. as are likely to occur in practice. The left-hand column, headed "Indication," contains the reading of the hydrometer, and on the same horizontal line, in the body of the table, in the "Temperature" column indicated by the thermometer, is found the corrected reading or true per cent.

The table is computed for tenths of a per cent.; but in practice only the nearest whole number of a per cent. need be used, excepting when large quantities are proved at one operation, in which case the decimal must be retained; otherwise, in taking out true per cents., if the decimal is .5 or less, drop it; if it is .6 or over, add a unit. Thus, page 697, column 23°, indication 123, the true per cent., 136.5, is called 136. Same page and column, indication 141, the true per cent., 153.6, is called 154.

Examples.—The hydrometer reads 130, the thermometer 29°; on page 697, in the temperature column 29°, and opposite indication 130, we find 141, which is the true per cent. of proof spirit in the liquor. This is the same as 41 *over proof*, according to the ordinary way of speaking.

Suppose the hydrometer reads 150 and the thermometer 85°; on page 715, in temperature column 85°, and against indication 150, we again find 141 for the true per cent.

It may happen that the hydrometer indicates the strength as under proof when it is really over, and *vice versa.*

Examples.—The hydrometer reads 89, the thermometer 29°. On page 696, column 29°, indication 89, we find the true per cent. 102, or 2 *over* proof.

The hydrometer reads 103, the thermometer 86°. On page 714, column 86°, indication 103, we find the true per cent. to be 92, or 8 *under* proof.

VOLUMES.

The correction required to reduce 100 gallons, measured at any temperature, to its volume at the standard temperature, 60° Fahr., is given in table of corrections to volume, page 719.

As the volumes contract with a decrease and expand with an increase of temperature, below 60° the correction is to be added, and above 60° to be subtracted.

Examples.—Suppose the cask was gauged at the time it was

inspected, and that at 30° it contained 121.4 gallons, while the hydrometer read 135. For temperature 30°, and opposite indication 135 (page 719), we find the correction to volume 1.5, "*add*"

Gallons gauged	121.4
1 per cent.	+ 1.2
.5 per cent.	+ .6
Gallons at 60° Fahr.	123.2

Suppose that at 85° it contained 124.8 gallons, while hydrometer reads 155. For temperature 85°, and opposite indication 155 (page 719), we find the correction to volume 1.3, "*subtract*"

Gallons gauged	124.8
1 per cent.	— 1.2
.3 per cent.	— .4
Gallons at 60° Fahr.	123.2

The above show that at 60° Fahr. the cask contains 123.2 gallons of spirits and of strength 146, as will be found from Table I. In order to find the equivalent number of gallons of proof spirit, multiply 123.2 by 1.46, which may be done thus with the least number of figures:—

Multiply by 1	123.2
Multiply by 4, and set back 1 digit	49.2[8]
Multiply by 6, and set back 2 digits	7.3[92]
	179.8[72]

The result shows a larger volume of proof spirit than the actual volume of liquor in the cask. This is because the liquor, being of strength 146, is *over* proof, and would require the addition of water to reduce it to proof.

TABLE II.

This is a table for gauging by means of the weight of the liquor and the true per cent. The following example fully illustrates its use:—

Example.—A cask of spirit of 141 per cent. strength (or 41 over proof) weighed 913 pounds net. We find—

900 pounds equal to	121.54 gallons
10 pounds equal to	1.35 gallons
3 pounds equal to	.40 gallons
Or contents	123.29

that is, 913 pounds of spirit of strength 141 is equivalent to 123.3 gallons at 60° Fahr.

The equivalent gallons for 10 pounds are found from the column 100 pounds by moving the decimal point one place to the left; those for three pounds from the column 300 pounds by moving the decimal point two places to the left.

TABLE III.

Gives the respective volumes of absolute alcohol and water contained in 100 volumes of spirits of different strength, and also the specific gravities of the mixtures, referred, for convenience, to the density of water at 60° Fahr. as unity.

This table will be found especially useful in reducing the strength of liquors by a definite amount.

To do this, divide the alcohol in the given strength by the alcohol in the required strength, multiply the quotient by the water in the required strength, and subtract the water in the given strength from the product. The remainder is the number of gallons of water to be added to 100 gallons of liquor of the given strength to produce a liquor of the required strength.

Example.—It is required to reduce liquor of 141 per cent. to proof.

We find on page 724, 141 per cent. contains 70.5 parts alcohol, and 32.86 parts water.

Page 723, 100 per cent. contains 50.0 parts alcohol, and 53.71 parts water.

Alcohol in 141 per cent.	70.50
Divide by alcohol in 100 per cent. = 50.00	1.41
Multiply by water in 100 per cent. = 53.71—	
50	70.50
3	4.23
.7	.99
.01	.01
	75.73
Subtract water in 141 per cent. =	32.86
Gallons of water to add to 100 gallons of 141 per cent.	42.87

or, to 100 gallons of 141 per cent. add 42.9 gallons of water, and the mixture will be proof spirit.

This rule is generally applicable for reducing to any per cent.; but when it is required to reduce to 100 per cent., it is sufficient to multiply the given per cent. by 53.71, and deduct the water in the given strength. Thus in the above example—

$$1.41 \times 53.71 - 32.86 = 75.73 - 32.86 = 42.87.$$

TABLE I.—*Showing the true per cents. of Proof Spirit for any indication of the Hydrometer at temperatures between 0° and 100° F.*

TRUE PER CENT.

Ind. 121 to 120. Temp 1° to 10°.

Indication.	TEMPERATURES.									
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
51	80.8	80.2	79.7	79.1	78.6	78.0	77.4	76.9	76.3	75.7
52	81.8	81.2	80.7	80.1	79.6	79.0	78.5	77.9	77.4	76.8
53	82.7	82.1	81.6	81.0	80.5	80.0	79.5	78.9	78.4	77.9
54	83.6	83.1	82.5	82.0	81.5	81.0	80.5	79.9	79.4	78.9
55	84.4	83.9	83.4	82.9	82.4	81.9	81.4	80.8	80.3	79.8
56	85.3	84.8	84.3	83.8	83.3	82.8	82.3	81.8	81.3	80.8
57	86.2	85.7	85.1	84.6	84.1	83.6	83.1	82.7	82.2	81.7
58	87.0	86.5	86.0	85.5	85.0	84.5	84.0	83.6	83.1	82.6
59	87.8	87.3	86.9	86.4	85.9	85.4	84.9	84.5	84.0	83.5
60	88.6	88.1	87.7	87.2	86.7	86.2	85.7	85.3	84.8	84.3
61	89.4	89.0	88.5	88.1	87.6	87.1	86.6	86.2	85.7	85.2
62	90.2	89.8	89.3	88.9	88.4	87.9	87.5	87.0	86.6	86.1
63	91.0	90.6	90.1	89.7	89.2	88.7	88.3	87.8	87.4	86.9
64	91.9	91.4	91.0	90.5	90.1	89.6	89.1	88.7	88.2	87.7
65	92.7	92.3	91.8	91.4	90.9	90.4	90.0	89.5	89.1	88.6
66	93.5	93.1	92.6	92.2	91.7	91.2	90.8	90.3	89.9	89.4
67	94.3	93.9	93.4	93.0	92.5	92.1	91.6	91.2	90.7	90.3
68	95.2	94.7	94.3	93.8	93.3	92.9	92.5	92.0	91.6	91.2
69	96.0	95.6	95.1	94.7	94.2	93.8	93.3	92.9	92.4	92.0
70	96.8	96.4	95.9	95.5	95.0	94.6	94.2	93.7	93.3	92.9
71	97.7	97.3	96.8	96.4	95.9	95.5	95.1	94.6	94.2	93.8
72	98.5	98.1	97.6	97.2	96.7	96.3	95.9	95.5	95.1	94.7
73	99.4	98.9	98.5	98.0	97.6	97.2	96.8	96.3	95.9	95.5
74	100.3	99.8	99.4	98.9	98.5	98.1	97.7	97.2	96.8	96.4
75	101.1	100.6	100.2	99.7	99.3	98.9	98.5	98.1	97.7	97.3
76	101.9	101.5	101.0	100.6	100.2	99.8	99.4	98.9	98.5	98.1
77	102.8	102.4	101.9	101.5	101.1	100.7	100.3	99.8	99.4	99.0
78	103.6	103.2	102.7	102.3	101.9	101.5	101.1	100.7	100.3	99.9
79	104.5	104.1	103.6	103.2	102.8	102.4	102.0	101.6	101.2	100.8
80	105.3	104.9	104.4	104.0	103.6	103.2	102.8	102.5	102.1	101.7
81	106.2	105.8	105.3	104.9	104.5	104.1	103.7	103.4	103.0	102.6
82	107.0	106.6	106.2	105.8	105.4	105.0	104.6	104.3	103.9	103.5
83	107.9	107.5	107.0	106.6	106.2	105.8	105.4	105.1	104.7	104.3
84	108.7	108.3	107.9	107.5	107.1	106.7	106.3	106.0	105.6	105.2
85	109.6	109.2	108.8	108.4	108.0	107.6	107.2	106.9	106.5	106.1
86	110.4	110.0	109.6	109.2	108.8	108.4	108.0	107.7	107.3	106.9
87	111.2	110.8	110.5	110.1	109.7	109.3	108.9	108.6	108.2	107.8
88	112.1	111.7	111.3	110.9	110.5	110.1	109.8	109.4	109.1	108.7
89	112.9	112.5	112.2	111.8	111.4	111.0	110.7	110.3	110.0	109.6
90	113.8	113.4	113.0	112.6	112.2	111.8	111.5	111.1	110.8	110.4
91	114.7	114.3	113.9	113.5	113.1	112.7	112.4	112.0	111.7	111.3
92	115.6	115.2	114.8	114.4	114.0	113.6	113.3	112.9	112.6	112.2
93	116.5	116.1	115.7	115.3	114.9	114.5	114.2	113.8	113.5	113.1
94	117.4	117.0	116.6	116.2	115.8	115.4	115.1	114.7	114.4	114.0
95	118.3	117.9	117.5	117.1	116.7	116.3	116.0	115.6	115.3	114.9
96	119.2	118.8	118.4	118.0	117.6	117.2	116.9	116.5	116.2	115.8
97	120.1	119.7	119.3	118.9	118.5	118.1	117.8	117.4	117.1	116.7
98	121.0	120.6	120.2	119.8	119.4	119.0	118.7	118.3	118.0	117.6
99	121.9	121.5	121.1	120.7	120.3	119.9	119.6	119.2	118.9	118.5
100	122.8	122.4	122.0	121.6	121.2	120.8	120.5	120.1	119.8	119.4
101	123.7	123.3	122.9	122.5	122.1	121.7	121.4	121.0	120.7	120.3
102	124.6	124.2	123.9	123.5	123.1	122.7	122.4	122.0	121.7	121.3
103	125.5	125.1	124.8	124.4	124.0	123.6	123.3	122.9	122.6	122.2
104	126.4	126.0	125.7	125.3	124.9	124.4	124.1	123.8	123.5	123.1
105	127.3	126.9	126.6	126.2	125.8	125.4	125.1	124.7	124.4	124.0
106	128.3	127.9	127.5	127.1	126.7	126.3	126.0	125.6	125.3	124.9
107	129.2	128.8	128.4	128.0	127.6	127.2	126.9	126.5	126.2	125.8
108	130.1	129.7	129.3	128.9	128.5	128.1	127.8	127.4	127.1	126.7
109	131.0	130.6	130.3	129.9	129.5	129.1	128.8	128.4	128.1	127.7
110	131.9	131.6	131.2	130.9	130.5	130.1	129.8	129.4	129.1	128.7
111	132.8	132.5	132.1	131.8	131.4	131.0	130.7	130.3	130.0	129.6
112	133.8	133.4	133.1	132.7	132.3	132.0	131.6	131.3	130.9	130.6
113	134.7	134.4	134.0	133.7	133.3	132.9	132.6	132.2	131.9	131.5
114	135.6	135.3	134.9	134.6	134.2	133.9	133.5	133.2	132.8	132.5
115	136.6	136.2	135.9	135.5	135.2	134.9	134.5	134.2	133.8	133.5
116	137.6	137.2	136.9	136.5	136.1	135.8	135.4	135.1	134.7	134.4
117	138.5	138.1	137.8	137.4	137.1	136.8	136.4	136.1	135.7	135.4
118	139.4	139.0	138.7	138.3	138.0	137.7	137.3	137.0	136.6	136.3
119	140.4	140.0	139.7	139.3	139.0	138.7	138.3	138.0	137.6	137.3
120	141.3	140.9	140.6	140.2	139.9	139.6	139.2	138.9	138.5	138.2

TRUE PER CENT.

Ind. 121 to 189. Temp. 1° to 10°

Indication.	TEMPERATURES									
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
121	142.2	141.9	141.5	141.2	140.9	140.6	140.2	139.9	139.5	139.2
122	143.1	142.8	142.4	142.1	141.8	141.5	141.1	140.8	140.4	140.1
123	144.1	143.8	143.4	143.1	142.8	142.5	142.1	141.8	141.4	141.1
124	145.0	144.7	144.3	144.0	143.7	143.4	143.0	142.7	142.3	142.0
125	145.9	145.6	145.3	145.0	144.7	144.4	144.0	143.7	143.3	143.0
126	146.9	146.6	146.2	145.9	145.6	145.3	144.9	144.6	144.2	143.9
127	147.8	147.5	147.1	146.8	146.5	146.2	145.8	145.5	145.1	144.8
128	148.7	148.4	148.0	147.7	147.4	147.1	146.7	146.4	146.0	145.7
129	149.6	149.3	148.9	148.6	148.3	148.0	147.7	147.3	147.0	146.7
130	150.6	150.3	149.9	149.6	149.3	149.0	148.6	148.3	147.9	147.6
131	151.5	151.2	150.8	150.5	150.2	149.9	149.5	149.2	148.8	148.5
132	152.4	152.1	151.7	151.4	151.1	150.8	150.4	150.1	149.7	149.4
133	153.3	153.0	152.6	152.3	152.0	151.7	151.4	151.0	150.7	150.4
134	154.2	153.9	153.6	153.3	153.0	152.7	152.3	152.0	151.6	151.3
135	155.2	154.9	154.5	154.2	153.9	153.6	153.2	152.9	152.5	152.2
136	156.1	155.8	155.4	155.1	154.8	154.5	154.1	153.8	153.4	153.1
137	157.1	156.8	156.4	156.1	155.8	155.5	155.1	154.8	154.4	154.1
138	158.0	157.7	157.3	157.0	156.7	156.4	156.0	155.7	155.3	155.0
139	158.9	158.6	158.2	157.9	157.6	157.3	156.9	156.6	156.2	155.9
140	159.8	159.5	159.1	158.8	158.5	158.2	157.9	157.5	157.2	156.9
141	160.8	160.5	160.1	159.8	159.5	159.2	158.8	158.5	158.1	157.8
142	161.7	161.4	161.0	160.7	160.4	160.1	159.7	159.4	159.0	158.7
143	162.6	162.3	161.9	161.6	161.3	161.0	160.7	160.3	160.0	159.7
144	163.6	163.2	162.9	162.5	162.2	161.9	161.6	161.2	160.9	160.6
145	164.5	164.2	163.8	163.5	163.2	162.9	162.6	162.2	161.9	161.6
146	165.3	165.0	164.7	164.4	164.1	163.8	163.5	163.1	162.8	162.5
147	166.2	165.9	165.6	165.3	165.0	164.7	164.4	164.0	163.7	163.4
148	167.1	166.8	166.5	166.2	165.9	165.6	165.3	164.9	164.6	164.3
149	168.0	167.7	167.4	167.1	166.8	166.5	166.2	165.9	165.6	165.3
150	168.9	168.6	168.3	168.0	167.7	167.4	167.1	166.8	166.5	166.2
151	169.8	169.5	169.2	168.9	168.6	168.3	168.0	167.7	167.4	167.1
152	170.7	170.4	170.1	169.8	169.5	169.2	168.9	168.6	168.3	168.0
153	171.6	171.3	171.0	170.7	170.4	170.1	169.8	169.5	169.2	168.9
154	172.5	172.2	171.9	171.6	171.3	171.0	170.7	170.4	170.1	169.8
155	173.3	173.1	172.8	172.6	172.3	172.0	171.7	171.3	171.0	170.7
156	174.2	174.0	173.7	173.5	173.2	172.9	172.6	172.2	171.9	171.6
157	175.1	174.9	174.6	174.4	174.1	173.8	173.5	173.2	172.9	172.6
158	176.0	175.8	175.5	175.3	175.0	174.7	174.4	174.1	173.8	173.5
159	176.9	176.7	176.4	176.2	175.9	175.6	175.3	175.0	174.7	174.4
160	177.8	177.6	177.3	177.1	176.8	176.5	176.2	175.9	175.6	175.3
161	178.7	178.5	178.2	178.0	177.7	177.4	177.1	176.8	176.5	176.2
162	179.6	179.4	179.1	178.9	178.6	178.3	178.0	177.7	177.4	177.1
163	180.4	180.2	179.9	179.7	179.4	179.1	178.8	178.6	178.3	178.0
164	181.1	181.1	180.8	180.6	180.3	180.0	179.7	179.5	179.2	178.9
165	182.1	181.9	181.6	181.4	181.1	180.8	180.5	180.3	180.0	179.7
166	183.0	182.8	182.5	182.3	182.0	181.7	181.4	181.2	180.9	180.6
167	183.8	183.6	183.3	183.1	182.8	182.5	182.3	182.0	181.8	181.5
168	184.7	184.4	184.2	183.9	183.7	183.4	183.2	182.9	182.7	182.4
169	185.5	185.3	185.0	184.8	184.5	184.2	184.0	183.7	183.5	183.2
170	186.4	186.1	185.9	185.6	185.4	185.1	184.9	184.6	184.4	184.1
171	187.2	186.9	186.7	186.4	186.2	186.0	185.8	185.5	185.2	185.0
172	188.0	187.8	187.5	187.3	187.0	186.8	186.5	186.3	186.0	185.8
173	188.9	188.6	188.4	188.1	187.9	187.7	187.4	187.2	186.9	186.7
174	189.7	189.5	189.2	189.0	188.7	188.5	188.2	188.0	187.7	187.5
175	190.6	190.3	190.1	189.8	189.6	189.4	189.1	188.9	188.6	188.4
176	191.4	191.2	190.9	190.7	190.5	190.3	190.0	189.8	189.5	189.3
177	192.3	192.0	191.8	191.5	191.3	191.1	190.9	190.6	190.4	190.2
178	193.1	192.9	192.6	192.4	192.2	192.0	191.8	191.5	191.3	191.1
179	193.9	193.7	193.4	193.2	193.0	192.8	192.6	192.3	192.1	191.9
180	194.7	194.5	194.2	194.0	193.8	193.6	193.4	193.2	193.0	192.8
181	195.4	195.2	194.9	194.7	194.5	194.3	194.1	193.9	193.7	193.5
182	196.2	196.0	195.7	195.5	195.3	195.1	194.9	194.7	194.5	194.3
183	196.9	196.7	196.4	196.2	196.0	195.8	195.6	195.5	195.3	195.1
184	197.6	197.4	197.2	197.0	196.8	196.6	196.4	196.3	196.1	195.9
185	198.3	198.1	197.9	197.7	197.5	197.3	197.1	197.0	196.8	196.6
186	199.1	198.9	198.7	198.5	198.3	198.1	197.9	197.8	197.6	197.4
187	199.8	199.6	199.5	199.3	199.1	198.9	198.7	198.6	198.4	198.2
188	....	....	....	200.0	199.8	199.6	199.4	199.3	199.1	198.9
189	....	....	....	....	....	....	....	....	199.9	199.7

TRUE PER CENT.

Ind. 51 to 120. Temp 11° to 20°.

Indication.	TEMPERATURES.									
	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°
51	75.1	74.5	74.0	73.4	72.8	72.2	71.7	71.1	70.6	70.0
52	76.2	75.7	75.1	74.6	74.0	73.4	72.9	72.3	71.8	71.2
53	77.3	76.8	76.2	75.7	75.1	74.5	74.0	73.4	72.9	72.3
54	78.3	77.8	77.2	76.7	76.1	75.6	75.0	74.5	73.9	73.4
55	79.3	78.8	78.2	77.7	77.2	76.7	76.1	75.6	75.0	74.5
56	80.3	79.8	79.2	78.7	78.2	77.7	77.2	76.6	76.1	75.6
57	81.2	80.7	80.1	79.6	79.1	78.6	78.1	77.6	77.1	76.6
58	82.1	81.6	81.1	80.6	80.1	79.6	79.1	78.6	78.1	77.6
59	83.0	82.5	82.0	81.5	81.0	80.5	80.0	79.6	79.1	78.6
60	83.8	83.3	82.9	82.4	81.9	81.4	80.9	80.5	80.0	79.5
61	84.7	84.2	83.8	83.3	82.8	82.3	81.8	81.4	80.9	80.4
62	85.6	85.1	84.7	84.2	83.7	83.2	82.7	82.3	81.8	81.3
63	86.4	85.9	85.5	85.0	84.5	84.0	83.6	83.1	82.7	82.2
64	87.2	86.8	86.3	85.9	85.4	84.9	84.5	84.0	83.6	83.1
65	88.1	87.6	87.2	86.7	86.2	85.8	85.3	84.9	84.4	84.0
66	88.9	88.4	88.0	87.5	87.0	86.6	86.1	85.7	85.2	84.8
67	89.8	89.3	88.9	88.4	87.9	87.5	87.0	86.6	86.1	85.7
68	90.7	90.2	89.8	89.3	88.8	88.4	87.9	87.5	87.0	86.6
69	91.5	91.0	90.6	90.1	89.6	89.2	88.8	88.3	87.9	87.5
70	92.4	91.9	91.5	91.0	90.5	90.1	89.7	89.2	88.8	88.4
71	93.3	92.8	92.4	91.9	91.4	91.0	90.6	90.1	89.7	89.3
72	94.2	93.7	93.3	92.8	92.3	91.9	91.5	91.0	90.6	90.2
73	95.0	94.6	94.1	93.7	93.2	92.8	92.4	91.9	91.5	91.1
74	95.9	95.5	95.0	94.6	94.1	93.7	93.3	92.8	92.4	92.0
75	96.8	96.4	95.9	95.5	95.0	94.6	94.2	93.7	93.3	92.9
76	97.7	97.3	96.8	96.4	95.9	95.5	95.1	94.6	94.2	93.8
77	98.6	98.2	97.7	97.3	96.8	96.4	96.0	95.5	95.1	94.7
78	99.5	99.1	98.6	98.2	97.7	97.3	96.9	96.4	96.0	95.6
79	100.4	100.0	99.5	99.1	98.6	98.2	97.8	97.3	96.9	96.5
80	101.3	100.9	100.4	100.0	99.5	99.1	98.7	98.2	97.8	97.4
81	102.2	101.8	101.3	100.9	100.5	100.1	99.6	99.2	98.7	98.3
82	103.1	102.7	102.2	101.8	101.4	101.0	100.5	100.1	99.6	99.2
83	103.9	103.5	103.1	102.7	102.3	101.9	101.5	101.0	100.6	100.2
84	104.8	104.4	104.0	103.6	103.2	102.8	102.4	101.9	101.5	101.1
85	105.7	105.3	104.9	104.5	104.1	103.7	103.3	102.8	102.4	102.0
86	106.5	106.1	105.8	105.4	105.0	104.6	104.2	103.7	103.3	102.9
87	107.4	107.0	106.7	106.3	105.9	105.5	105.1	104.6	104.2	103.8
88	108.3	107.9	107.6	107.2	106.8	106.4	106.0	105.5	105.1	104.7
89	109.2	108.8	108.5	108.1	107.7	107.3	106.9	106.4	106.0	105.6
90	110.0	109.7	109.3	109.0	108.6	108.2	107.8	107.3	106.9	106.5
91	110.9	110.6	110.2	109.9	109.5	109.1	108.7	108.2	107.8	107.4
92	111.8	111.5	111.1	110.8	110.4	110.0	109.6	109.1	108.7	108.3
93	112.7	112.4	112.0	111.7	111.3	110.9	110.5	110.0	109.6	109.2
94	113.6	113.3	112.9	112.6	112.2	111.8	111.4	111.0	110.6	110.2
95	114.5	114.2	113.8	113.5	113.1	112.7	112.3	111.9	111.5	111.1
96	115.4	115.1	114.7	114.4	114.0	113.6	113.2	112.8	112.4	112.0
97	116.3	116.0	115.6	115.3	114.9	114.5	114.1	113.7	113.3	112.9
98	117.2	116.9	116.5	116.2	115.8	115.4	115.0	114.7	114.3	113.9
99	118.1	117.8	117.4	117.1	116.7	116.3	115.9	115.6	115.2	114.8
100	119.1	118.7	118.4	118.0	117.7	117.3	116.9	116.5	116.1	115.7
101	120.0	119.6	119.3	118.9	118.6	118.2	117.8	117.5	117.1	116.7
102	120.9	120.6	120.2	119.9	119.5	119.1	118.7	118.4	118.0	117.6
103	121.8	121.5	121.1	120.8	120.4	120.0	119.6	119.3	118.9	118.5
104	122.7	122.4	122.0	121.7	121.3	120.9	120.5	120.2	119.8	119.4
105	123.6	123.3	122.9	122.6	122.2	121.8	121.4	121.1	120.7	120.3
106	124.5	124.2	123.8	123.5	123.1	122.7	122.4	122.0	121.7	121.3
107	125.5	125.1	124.8	124.4	124.1	123.7	123.3	123.0	122.6	122.2
108	126.4	126.0	125.7	125.3	125.0	124.6	124.2	123.9	123.5	123.1
109	127.4	127.0	126.7	126.3	126.0	125.6	125.2	124.9	124.5	124.1
110	128.3	128.0	127.6	127.3	126.9	126.5	126.1	125.8	125.4	125.0
111	129.3	128.9	128.6	128.2	127.9	127.5	127.1	126.8	126.4	126.0
112	130.3	129.9	129.6	129.2	128.9	128.5	128.1	127.8	127.4	127.0
113	131.2	130.8	130.5	130.1	129.8	129.4	129.0	128.7	128.3	127.9
114	132.2	131.8	131.5	131.1	130.8	130.4	130.0	129.7	129.3	128.9
115	133.2	132.8	132.5	132.1	131.8	131.4	131.0	130.7	130.3	129.9
116	134.1	133.7	133.4	133.0	132.7	132.3	132.0	131.6	131.3	130.9
117	135.1	134.7	134.4	134.0	133.7	133.3	132.9	132.6	132.2	131.8
118	136.0	135.6	135.3	134.9	134.6	134.2	133.9	133.5	133.2	132.8
119	137.0	136.6	136.3	135.9	135.6	135.2	134.9	134.5	134.2	133.8
120	137.9	137.5	137.2	136.8	136.5	136.1	135.8	135.4	135.1	134.7

TRUE PER CENT.

Ind. 121 to 191. Temp. 11° to 20°.

Indication.	TEMPERATURES.									
	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°
121	138.9	138.5	138.2	137.8	137.5	137.1	136.8	136.4	136.1	135.7
122	139.8	139 5	139.1	138.8	138.5	138.1	137.8	137.4	137.1	136.7
123	140.8	140.4	140.1	139.7	139.4	139.0	138.7	138.3	138.0	137.6
124	141.7	141.4	141.0	140.7	140.4	140.0	139.7	139.3	139.0	138.6
125	142 7	142.3	142.0	141.6	141.3	141.0	140.6	140.3	139.9	139.6
126	143.6	143.3	142.9	142.6	142.3	141.9	141.6	141.2	140.9	140.5
127	144.5	144.2	143.8	143.5	143.2	142.8	142.5	142.1	141.8	141.4
128	145.4	145.1	144.7	144.4	144.1	143.8	143.4	143.1	142.7	142.4
129	146.4	146.1	145.7	145.4	145.1	144.7	144.4	144.0	143.7	143.3
130	147.3	147.0	146.6	146.3	146.0	145.6	145.3	144.9	144.6	144.2
131	148.2	147.9	147.5	147.2	146.9	146.6	146.2	145.9	145.5	145.2
132	149.1	148.8	148.5	148.2	147.9	147.5	147.2	146.8	146.5	146.1
133	150.1	149 8	149.4	149.1	148.8	148.5	148.1	147.8	147.4	147.1
134	151.0	150.7	150.3	150.0	149.7	149.4	149.0	148.7	148.3	148.0
135	151.9	151.6	151.3	151.0	150.7	150.4	150.0	149.7	149.3	149.0
136	152.8	152.5	152.2	151.9	151.6	151.3	150.9	150.6	150.2	149.9
137	153.8	153.5	153.2	152.9	152.6	152.3	151.9	151.6	151.2	150.9
138	154.7	154.4	154.1	153.8	153.5	153.2	152.8	152.5	152.1	151.8
139	155.6	155.3	155.0	154.7	154.4	154.1	153.7	153.4	153.0	152.7
140	156.6	156.3	156.0	155.7	155.4	155.1	154.7	154.4	154.0	153.7
141	157.5	157.2	156.9	156.6	156.3	156.0	155.6	155.3	154.9	154.6
142	158.4	158.1	157 8	157.5	157.2	156.9	156.6	156.2	155.9	155.6
143	159.4	159.1	158.8	158.5	158.2	157.9	157.5	157.2	156.8	156.5
144	160.3	160.0	159.8	159.5	159.2	158.9	158.5	158.2	157.8	157.5
145	161.3	161.0	160.7	160.4	160.1	159.8	159.4	159.1	158.7	158.4
146	162.2	161 9	161.6	161.3	161.0	160.7	160.4	160.0	159.7	159.4
147	163.1	162.8	162.6	162.3	162.0	161.7	161.3	161.0	160.6	160.3
148	164.0	163.7	163.5	163.2	162.9	162.6	162.3	161.9	161.6	161.3
149	165.0	164.7	164.5	164.2	163.9	163.6	163.2	162.9	162.5	162.2
150	165.9	165.6	165.4	165.1	164.8	164.5	164.2	163.8	163.5	163.2
151	166.8	166.5	166.3	166.0	165.7	165.4	165.1	164.7	164.4	164.1
152	167.7	167.4	167.2	166.9	166.6	166.3	166.0	165.7	165.4	165.1
153	168.6	168.4	168.1	167.9	167.6	167.3	167.0	166.6	166.3	166.0
154	169.5	169.3	169.0	168.8	168.5	168.2	167.9	167.5	167.2	166.9
155	170.4	170.2	169.9	169.7	169.4	169.1	168.8	168.5	168.2	167.9
156	171.3	171.1	170.8	170.6	170.3	170.0	169.7	169.4	169.1	168.8
157	172.3	172.1	171.8	171.6	171.3	171.0	170.7	170.4	170.1	169.8
158	173.2	173 0	172.7	172.5	172.2	171.9	171.6	171.3	171.0	170.7
159	174.1	173.9	173.6	173.4	173.1	172.8	172.5	172.2	171.9	171.6
160	175.0	174.8	174.5	174.3	174.0	173.7	173.4	173.2	172.9	172.6
161	175.9	175.7	175.4	175.2	174.9	174.6	174.3	174.1	173.8	173.5
162	176.8	176 6	176.3	176.1	175.8	175.5	175.2	175.0	174.7	174.4
163	177.7	177.5	177.2	177.0	176.7	176.4	176.1	175.9	175.6	175.3
164	178 6	178.4	178.1	177.9	177.6	177.3	177.0	176.8	176.5	176.2
165	179.4	179.2	178.9	178.7	178.4	178.1	177.9	177.6	177.4	177.1
166	180.3	180.1	179.8	179.6	179.3	179.0	178.8	178.5	178.3	178.0
167	181.2	181.0	180.7	180.5	180.2	179.9	179.7	179.4	179.2	178.9
168	182.1	181.9	181.6	181.4	181.1	180.8	180.5	180.3	180.0	179.8
169	182 9	182.7	182.4	182.2	181.9	181.7	181.4	181.2	180.9	180.7
170	183.8	183.6	183.3	183.1	182.8	182.5	182.3	182.0	181.8	181.5
171	184.7	184.5	184.2	184.0	183.7	183.4	183.2	182.9	182.7	182.4
172	185.6	185.3	185.1	184.8	184.6	184.3	184.1	183.8	183.6	183.3
173	186 4	186.2	185.9	185.7	185.4	185.2	184.9	184.7	184.4	184.2
174	187.3	187.0	186.8	186.5	186.3	186.1	185.8	185.6	185.3	185.1
175	188 2	187.9	187.7	187.4	187.2	187.0	186.7	186.5	186.2	186.0
176	189.1	188.8	188.6	188.3	188.1	187.8	187.6	187.3	187.1	186.8
177	189.9	189.7	189.4	189.2	188.9	188.7	188.4	188.2	187.9	187.7
178	190 8	190.6	190.3	190.1	189.8	189.6	189.3	189.1	188.8	188.6
179	191.7	191.4	191.2	190.9	190.7	190.5	190.2	190.0	189.7	189.5
180	192.6	192.3	192.1	191.8	191.6	191.4	191.1	190.9	190.6	190.4
181	193.3	193.1	192.8	192.6	192.4	192.2	192.0	191.7	191.5	191.3
182	194.1	193.9	193.6	193.4	193.2	193.0	192.8	192.5	192.3	192.1
183	194.9	194 7	194.4	194.2	194.0	193.8	193.6	193.3	193.1	192.9
184	195.7	195.5	195 2	195.0	194.8	194.6	194.4	194.1	193.9	193.7
185	196.4	196.2	196.0	195.8	195.6	195.4	195.2	194.9	194.7	194.5
186	197.2	197.0	196 8	196.6	196.4	196.2	196.0	195.8	195.6	195.4
187	198.0	197.8	197.6	197.4	197.2	197.0	196.8	196.6	196.4	196.2
188	198.7	198.5	198.3	198.1	197.9	197.7	197.5	197.4	197.2	197.0
189	199.5	199.3	199.1	198.9	198.7	198.5	198.3	198.2	198.0	197.8
190	....	....	199.9	199.7	199.5	199.3	199.1	199.0	198.8	198.6
191	....	....	....	....	....	....	199.9	199.8	199.7	199.5

TRUE PER CENT.

Ind. 51 to 120. Temp. 21° to 30°.

Indication.	TEMPERATURES.									
	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
51	69.5	69.0	68.4	67.9	67.4	66.9	66.3	65.8	65.2	64.7
52	70.7	70.2	69.6	69.1	68.6	68.0	67.5	66.9	66.4	65.8
53	71.8	71.3	70.7	70.2	69.7	69.1	68.6	68.0	67.5	66.9
54	72.9	72.4	71.9	71.4	70.9	70.3	69.7	69.2	68.6	68.0
55	74.0	73.5	73.0	72.5	72.0	71.4	70.8	70.3	69.7	69.1
56	75.1	74.6	74.1	73.6	73.1	72.5	71.9	71.3	70.7	70.1
57	76.1	75.6	75.1	74.6	74.1	73.5	72.9	72.4	71.8	71.2
58	77.1	76.6	76.1	75.6	75.1	74.5	73.9	73.4	72.8	72.2
59	78.1	77.6	77.1	76.6	76.1	75.5	75.0	74.4	73.9	73.3
60	79.0	78.5	78.1	77.6	77.1	76.6	76.0	75.5	74.9	74.4
61	79.9	79.5	79.0	78.6	78.1	77.6	77.0	76.5	75.9	75.4
62	80.9	80.4	80.0	79.5	79.1	78.6	78.0	77.5	76.9	76.4
63	81.8	81.3	80.9	80.4	80.0	79.5	78.9	78.4	77.8	77.3
64	82.7	82.2	81.8	81.3	80.9	80.4	79.8	79.3	78.7	78.2
65	83.6	83.1	82.7	82.2	81.8	81.3	80.7	80.2	79.6	79.1
66	84.4	84.0	83.5	83.1	82.7	82.2	81.7	81.1	80.6	80.1
67	85.3	84.9	84.4	84.0	83.6	83.1	82.6	82.0	81.5	81.0
68	86.2	85.8	85.3	84.9	84.5	84.0	83.5	82.9	82.4	81.9
69	87.1	86.7	86.2	85.8	85.4	84.9	84.4	83.8	83.3	82.8
70	88.0	87.6	87.1	86.7	86.3	85.8	85.3	84.8	84.3	83.8
71	88.9	88.5	88.0	87.6	87.2	86.7	86.2	85.7	85.2	84.7
72	89.8	89.4	88.9	88.5	88.1	87.6	87.1	86.6	86.1	85.6
73	90.7	90.3	89.8	89.4	89.0	88.5	88.0	87.5	87.0	86.5
74	91.6	91.2	90.7	90.3	89.9	89.4	88.9	88.5	88.0	87.5
75	92.5	92.1	91.6	91.2	90.8	90.3	89.8	89.4	88.9	88.4
76	93.4	93.0	92.5	92.1	91.7	91.3	90.8	90.3	89.9	89.4
77	94.2	93.8	93.4	93.0	92.6	92.2	91.7	91.2	90.8	90.3
78	95.2	94.8	94.4	94.0	93.6	93.2	92.7	92.2	91.8	91.3
79	96.1	95.7	95.3	94.9	94.5	94.1	93.6	93.1	92.7	92.2
80	97.0	96.6	96.2	95.8	95.4	95.0	94.5	94.0	93.6	93.1
81	97.9	97.5	97.1	96.7	96.3	95.9	95.5	95.0	94.6	94.1
82	96.8	98.4	98.0	97.6	97.2	96.8	96.4	95.9	95.5	95.0
83	99.8	99.4	98.9	98.5	98.1	97.7	97.3	96.8	96.4	95.9
84	100.7	100.3	99.8	99.4	99.0	98.6	98.2	97.7	97.3	96.8
85	101.6	101.2	100.7	100.3	99.9	99.5	99.1	98.6	98.2	97.8
86	102.5	102.1	101.7	101.3	100.9	100.5	100.1	99.6	99.2	98.7
87	103.4	103.0	102.6	102.2	101.8	101.4	101.0	100.5	100.1	99.7
88	104.3	103.9	103.5	103.1	102.7	102.3	101.9	101.5	101.1	100.7
89	105.2	104.8	104.4	104.0	103.6	103.2	102.8	102.4	102.0	101.6
90	106.1	105.7	105.3	104.9	104.5	104.1	103.7	103.3	102.9	102.5
91	107.0	106.6	106.2	105.8	105.4	105.0	104.6	104.3	103.9	103.5
92	107.9	107.5	107.1	106.7	106.3	105.9	105.5	105.2	104.8	104.4
93	108.8	108.4	108.1	107.7	107.3	106.9	106.5	106.2	105.8	105.4
94	109.8	109.4	109.0	108.6	108.2	107.8	107.4	107.1	106.7	106.3
95	110.7	110.3	109.9	109.5	109.1	108.7	108.3	108.0	107.6	107.2
96	111.6	111.2	110.9	110.5	110.1	109.7	109.3	108.9	108.5	108.1
97	112.5	112.1	111.8	111.4	111.0	110.6	110.2	109.9	109.5	109.1
98	113.5	113.1	112.7	112.3	111.9	111.5	111.1	110.8	110.4	110.0
99	114.4	114.0	113.7	113.3	112.9	112.5	112.1	111.8	111.4	111.0
100	115.3	114.9	114.6	114.2	113.8	113.4	113.0	112.7	112.3	111.9
101	116.3	115.9	115.5	115.1	114.7	114.3	113.9	113.6	113.2	112.8
102	117.2	116.8	116.5	116.1	115.7	115.3	114.9	114.6	114.2	113.8
103	118.1	117.7	117.4	117.0	116.6	116.2	115.8	115.5	115.1	114.7
104	119.0	118.6	118.3	117.9	117.5	117.1	116.8	116.4	116.1	115.7
105	119.9	119.6	119.2	118.9	118.5	118.1	117.8	117.4	117.1	116.7
106	120.9	120.5	120.2	119.8	119.4	119.0	118.7	118.3	118.0	117.6
107	121.8	121.5	121.1	120.8	120.4	120.0	119.7	119.3	119.0	118.6
108	122.7	122.4	122.0	121.7	121.3	120.9	120.6	120.2	119.9	119.5
109	123.7	123.4	123.0	122.7	122.3	121.9	121.6	121.2	120.9	120.5
110	124.6	124.3	123.9	123.6	123.2	122.8	122.5	122.1	121.8	121.4
111	125.6	125.3	124.9	124.6	124.2	123.8	123.5	123.1	122.8	122.4
112	126.6	126.3	125.9	125.6	125.2	124.8	124.5	124.1	123.8	123.4
113	127.5	127.2	126.8	126.5	126.1	125.8	125.4	125.1	124.7	124.4
114	128.5	128.2	127.8	127.5	127.1	126.7	126.4	126.0	125.7	125.3
115	129.5	129.2	128.8	128.5	128.1	127.7	127.4	127.0	126.7	126.3
116	130.5	130.2	129.8	129.5	129.1	128.7	128.4	128.0	127.7	127.3
117	131.4	131.1	130.7	130.4	130.0	129.6	129.3	128.9	128.6	128.2
118	132.4	132.1	131.7	131.4	131.0	130.6	130.3	129.9	129.6	129.2
119	133.4	133.1	132.7	132.4	132.0	131.6	131.3	130.9	130.6	130.2
120	134.3	134.0	133.6	133.3	132.9	132.6	132.2	131.9	131.5	131.2

TRUE PER CENT.

Ind. 121 to 193. Temp 21° to 30°.

Indication.	TEMPERATURES.									
	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
121	135.3	135.0	134.6	134.3	133.9	133.5	133.2	132 8	132.5	132.1
122	136.3	135.9	135.6	135.2	134.8	134.5	134.1	133 8	133.4	133.1
123	137.2	136.9	136.5	136.2	135.8	135.5	135.1	134 8	134.4	134.1
124	138.2	137.9	137.5	137.2	136.8	136.5	136.1	135 8	135.4	135.1
125	139.2	138.8	138.5	138.1	137.7	137.4	137.0	136.7	136.3	136.0
126	140.1	139.8	139.4	139.1	138.7	138.3	138.0	137.6	137.3	136.9
127	141.0	140.7	140.3	140.0	139.6	139.2	138.9	138.6	138.2	137.9
128	142.0	141.7	141.3	141.0	140.6	140.2	139.9	139.5	139.2	138.8
129	142.9	142.6	142.2	141.9	141.5	141.2	140.8	140.5	140.1	139.8
130	143.9	143.5	143.2	142.8	142.5	142.1	141.8	141.4	141.1	140.7
131	144.9	144.5	144.2	143.8	143.5	143.1	142.8	142.4	142.1	141.7
132	145.8	145.4	145.1	144.7	144.4	144.1	143.7	143.3	143.0	142.6
133	146.8	146.4	146.1	145.7	145.4	145.1	144.7	144.3	144.0	143.6
134	147.7	147.3	147.0	146.6	146.3	146.0	145.6	145.3	144.9	144.6
135	148.7	148.3	148.0	147.6	147.3	146.9	146.6	146.2	145.9	145.5
136	149.6	149.2	148.9	148.5	148.2	147.9	147.5	147.2	146.8	146.5
137	150.6	150.2	149.9	149.5	149.2	148.8	148.5	148.1	147.8	147.4
138	151.5	151.1	150.8	150.4	150.1	149.8	149.4	149.1	148.7	148.4
139	152.4	152.1	151.7	151.4	151.1	150.7	150.4	150.0	149.7	149.3
140	153.4	153.0	152.7	152.3	152.0	151.7	151.3	151.0	150.6	150.3
141	154.3	154.0	153.6	153.3	153.0	152.7	152.3	152.0	151.6	151.3
142	155.3	155.0	154.6	154.3	154.0	153.7	153.3	153.0	152.6	152.3
143	156.2	155.9	155.5	155.2	154.9	154.6	154.2	153.9	153.5	153.2
144	157.2	156.9	156.5	156.2	155.9	155.6	155.2	154.9	154.5	154.2
145	158.1	157.8	157.5	157.2	156.9	156.6	156.2	155.8	155.5	155.1
146	159.1	158.8	158.4	158.1	157.8	157.5	157.1	156.8	156.4	156.1
147	160.0	159.7	159.4	159.1	158.8	158.5	158.1	157.8	157.4	157.1
148	161.0	160.7	160.3	160.0	159.7	159.4	159.0	158.7	158.3	158.0
149	162.9	161.6	161.3	161.0	160.7	160.4	160.0	159.7	159.3	159.0
150	162.8	162.5	162.2	161.9	161.6	161.3	160.9	160.6	160.2	159.9
151	163.8	163.5	163.1	162.8	162.5	162.2	161.9	161.5	161.2	160.9
152	164.8	164.5	164.1	163.8	163.5	163.2	162.9	162.5	162.2	161.9
153	165.7	165.4	165.0	164.7	164.4	164.1	163.8	163.4	163.1	162.8
154	166.6	166.3	166.0	165.7	165.4	165.1	164.8	164.4	164.1	163.8
155	167.6	167.3	166.9	166.6	166.3	166.0	165.7	165.4	165.1	164.8
156	168.5	168.2	167.9	167.6	167.3	167.0	166.7	166.3	166.0	195.7
157	169.5	169.2	168.8	168.5	168.2	167.9	167.6	167.3	167.0	166.7
158	170.4	170.1	169.8	169.5	169.2	168.9	168.6	168.3	168.0	167.7
159	171.3	171.0	170.7	170.4	170.1	169.8	169.5	169.2	168.9	168.6
160	172.3	172.0	171.7	171.4	171.1	170.8	170.5	170.1	169.8	169.5
161	173.2	172.9	172.6	172.3	172.0	171.7	171.4	171.0	170.7	170.4
162	174.1	173.8	173.5	173.2	172.9	172.6	172.3	172.0	171.7	171.4
163	175.0	174.7	174.4	174.1	173.8	173.5	173.2	172.9	172.6	172.3
164	175.9	175.6	175.3	175.0	174.7	174.4	174.1	173.8	173.5	173.2
165	176.8	176.5	176.3	176.0	175.7	175.4	175.1	174.7	174.4	174.1
166	177.7	177.4	177.2	176.9	176.6	176.3	176.0	175.7	175.4	175.1
167	178.6	178.3	178.1	177.8	177.5	177.2	176.9	176.6	176.3	176.0
168	179.5	179.2	179.0	178.7	178.4	178.1	177.8	177.5	177.2	176.9
169	180.4	180.1	179.9	179.6	179.3	179.0	178.7	178.5	178.2	177.9
170	181.2	181.0	180.7	180.5	180.2	179.9	179.6	179.4	179.1	178.8
171	182.1	181.9	181.[illegible]	181.4	181.1	180.8	180.5	180.3	180.0	179.7
172	183.0	182.8	182.5	182.3	182.0	181.7	181.4	181.2	180.9	180.6
173	183.9	183.7	183.4	183.2	182.9	182.6	182.3	182.1	181.8	181.5
174	184.8	184.6	184.3	184.1	183.8	183.5	183.2	183.0	182.7	182.4
175	185.7	185.5	185.2	185.0	184.7	184.4	184.1	183.9	183.6	183.3
176	186.6	186.3	186.1	185.8	185.6	185.3	185.0	184.8	184.5	184.2
177	187.5	187.2	187.0	186.7	186.5	186.2	186.0	185.7	185.5	185.2
178	188.4	188.1	187.9	187.6	187.4	187.1	186.9	186.6	186.4	186.1
179	189.3	189.0	188.8	188.5	188.3	188.0	187.8	187.5	187.3	187.0
180	190.2	189.9	189.7	189.4	189.2	188.9	188.6	188.4	188.1	187.8
181	191.1	190.8	190.6	190.3	190.1	189.8	189.5	189.3	189.0	188.7
182	191.9	191.6	191.4	191.1	190.9	190.6	190.4	190.1	189.9	189.6
183	192.7	192.5	192.2	192.0	191.8	191.5	191.3	191.0	190.8	190.5
184	193.5	193.3	193.0	192.8	192.6	192.3	192.1	191.8	191.6	191.3
185	194.3	194.1	193.9	193.7	193.5	193.2	193.0	192.7	192.5	192.2
186	195.2	195.0	194.7	194.5	194.3	194.0	193.8	193.5	193.3	193.0
187	196.0	195.8	195.6	195.4	195.2	194.9	194.7	194.4	194.2	193.9
188	196.8	196.6	196.4	196.2	196.0	195.8	195.5	195.3	195.0	194.8
189	197.6	197.4	197.3	197.1	196.9	196.6	196.4	196.1	195.9	195.6
190	198.4	198.2	198.1	197.9	197.7	197.6	197.3	197.1	196.8	196.5
191	199.3	199 1	199.0	198.8	198.6	198.4	198.1	197.9	197.6	197.4
192	....	199.9	199.7	199.6	199.4	199.2	199.0	198.7	198.5	198.3
193	....	....	....	....	....	....	199.9	199.6	199.4	199.2

TRUE PER CENT.

Ind. 1 to 65. Temp. 31° to 40°.

Indication.	TEMPERATURES.									
	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°
1	1.7	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0
2	2.7	2.7	2.8	2.8	2.9	2.9	2.9	3.0	3.0	3.0
3	3.7	3.7	3.8	3.8	3.9	3.9	3.9	4.0	4.0	4.0
4	4.7	4.7	4.8	4.8	4.9	4.9	4.9	5.0	5.0	5.0
5	5.7	5.7	5.8	5.8	5.9	5.9	5.9	6.0	6.0	6.0
6	6.7	6.8	6.8	6.9	6.9	6.9	6.9	7.0	7.0	7.0
7	7.7	7.8	7.8	7.9	7.9	7.9	7.9	8.0	8.0	8.0
8	8.8	8.8	8.9	8.9	9.0	9.0	9.0	9.0	9.0	9.0
9	9.8	9.8	9.9	9.9	10.0	10.0	10.0	10.1	10.1	10.1
10	10.9	10.9	11.0	11.0	11.1	11.1	11.1	11.2	11.2	11.2
11	12.0	12.0	12.1	12.1	12.2	12.2	12.2	12.3	12.3	12.3
12	13.1	13.2	13.2	13.3	13.3	13.3	13.3	13.3	13.3	13.3
13	14.2	14.3	14.3	14.4	14.4	14.4	14.4	14.4	14.4	14.4
14	15.3	15.4	15.4	15.5	15.5	15.5	15.5	15.5	15.5	15.5
15	16.4	16.5	16.5	16.6	16.6	16.6	16.6	16.6	16.6	16.6
16	17.5	17.6	17.6	17.7	17.7	17.7	17.7	17.7	17.7	17.7
17	18.6	18.7	18.7	18.8	18.8	18.8	18.8	18.7	18.7	18.7
18	19.7	19.8	19.8	19.9	19.9	19.9	19.9	19.8	19.8	19.8
19	21.0	21.0	21.1	21.1	21.1	21.1	21.1	21.0	21.0	20.9
20	22.3	22.3	22.4	22.4	22.4	22.4	22.4	22.3	22.3	22.3
21	23.6	23.6	23.6	23.6	23.6	23.6	23.5	23.5	23.4	23.4
22	24.8	24.8	24.8	24.8	24.8	24.7	24.7	24.6	24.6	24.5
23	26.0	26.0	25.9	25.9	25.9	25.8	25.8	25.7	25.7	25.6
24	27.2	27.2	27.1	27.1	27.1	27.0	27.0	26.9	26.9	26.8
25	28.4	28.3	28.3	28.2	28.2	28.1	28.1	28.0	28.0	27.9
26	29.7	29.7	29.6	29.6	29.5	29.4	29.3	29.3	29.2	29.1
27	31.2	31.1	31.1	31.0	30.9	30.8	30.7	30.6	30.5	30.4
28	32.6	32.5	32.4	32.3	32.2	32.1	32.0	31.8	31.7	31.6
29	34.0	33.9	33.8	33.7	33.6	33.5	33.3	33.2	33.0	32.9
30	35.4	35.2	35.1	34.9	34.8	34.7	34.5	34.4	34.2	34.1
31	36.7	36.6	36.4	36.3	36.1	35.9	35.8	35.6	35.5	35.3
32	38.3	38.1	38.0	37.8	37.6	37.4	37.2	36.9	36.7	36.5
33	39.9	39.7	39.4	39.2	39.0	38.8	38.5	38.3	38.0	37.8
34	41.4	41.2	40.9	40.7	40.4	40.1	39.9	39.6	39.4	39.1
35	42.9	42.7	42.4	42.2	41.9	41.6	41.3	41.1	40.8	40.5
36	44.4	44.1	43.9	43.6	43.3	43.0	42.7	42.4	42.1	41.8
37	45.8	45.5	45.2	44.9	44.6	44.3	44.0	43.7	43.4	43.1
38	47.1	46.8	46.5	46.2	45.9	45.6	45.3	45.0	44.7	44.4
39	48.5	48.2	47.8	47.5	47.2	46.9	46.6	46.2	45.9	45.6
40	49.9	49.5	49.2	48.8	48.5	48.2	47.8	47.5	47.1	46.8
41	51.2	50.8	50.5	50.1	49.7	49.4	49.0	48.7	48.3	48.0
42	52.6	52.2	51.8	51.4	51.0	50.6	50.2	49.9	49.5	49.1
43	54.0	53.6	53.1	52.7	52.3	51.9	51.5	51.1	50.7	50.3
44	55.4	54.9	54.5	54.0	53.6	53.2	52.8	52.3	51.9	51.5
45	56.7	56.3	55.8	55.4	54.9	54.5	54.1	53.6	53.2	52.8
46	58.1	57.6	57.2	56.7	56.2	55.8	55.3	54.9	54.4	54.0
47	59.4	58.9	58.4	57.9	57.4	57.0	56.5	56.1	55.6	55.2
48	60.7	60.2	59.7	59.2	58.7	58.2	57.8	57.3	56.9	56.4
49	61.9	61.4	60.9	60.4	59.9	59.4	58.9	58.5	58.0	57.5
50	63.1	62.6	62.2	61.7	61.3	60.8	60.2	59.7	59.1	58.6
51	64.2	63.8	63.3	62.9	62.4	61.9	61.4	60.8	60.3	59.8
52	65.3	64.9	64.4	64.0	63.5	63.0	62.5	61.9	61.4	60.9
53	66.4	65.9	65.5	65.0	64.5	64.0	63.5	63.1	62.6	62.1
54	67.5	67.0	66.5	66.0	65.5	65.0	64.5	64.1	63.6	63.1
55	68.6	68.1	67.6	67.1	66.6	66.1	65.6	65.2	64.7	64.2
56	69.6	69.1	68.6	68.1	67.6	67.1	66.6	66.2	65.7	65.2
57	70.6	70.1	69.7	69.2	68.7	68.2	67.7	67.3	66.8	66.3
58	71.7	71.2	70.7	70.2	69.7	69.2	68.7	68.3	67.8	67.3
59	72.8	72.3	71.7	71.2	70.7	70.2	69.7	69.3	68.8	68.3
60	73.9	73.4	72.8	72.3	71.8	71.3	70.8	70.3	69.8	69.3
61	74.9	74.4	73.8	73.3	72.8	72.3	71.8	71.4	70.9	70.4
62	75.9	75.4	74.8	74.3	73.8	73.3	72.8	72.4	71.9	71.4
63	76.8	76.3	75.9	75.4	74.9	74.4	73.9	73.4	72.9	72.4
64	77.7	77.3	76.8	76.4	75.9	75.4	74.9	74.4	73.9	73.4
65	78.7	78.2	77.8	77.3	76.9	76.4	75.9	75.4	74.9	74.4

TRUE PER CENT.

Ind. 66 to 130. Temp. 31° to 40°.

Indication.	TEMPERATURES.									
	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°
66	79.6	79.2	78.7	78.3	77.8	77.3	76.9	76.4	76.0	75.5
67	80.5	80.1	79.6	79.2	78.7	78.3	77.8	77.4	76.9	76.5
68	81.5	81.0	80.6	80.1	79.7	79.2	78.8	78.3	77.9	77.4
69	82.4	81.9	81.5	81.0	80.6	80.1	79.7	79.2	78.8	78.3
70	83.3	82.9	82.4	82.0	81.5	81.1	80.6	80.2	79.7	79.3
71	84.3	83.8	83.4	82.9	82.5	82.1	81.6	81.2	80.7	80.3
72	85.2	84.7	84.3	83.8	83.4	83.0	82.5	82.1	81.6	81.2
73	86.1	85.7	85.2	84.8	84.4	83.9	83.5	83.0	82.6	82.1
74	87.1	86.6	86.2	85.7	85.3	84.9	84.4	84.0	83.5	83.1
75	88.0	87.6	87.1	86.7	86.3	85.9	85.4	85.0	84.5	84.1
76	89.0	88.5	88.1	87.6	87.2	86.8	86.3	85.9	85.4	85.0
77	89.9	89.4	89.0	88.5	88.1	87.7	87.2	86.8	86.3	85.9
78	90.9	90.4	90.0	89.5	89.1	88.7	88.2	87.8	87.3	86.9
79	91.8	91.3	90.9	90.4	90.0	89.6	89.2	88.7	88.3	87.9
80	92.7	92.3	91.8	91.4	91.0	90.6	90.1	89.7	89.2	88.8
81	93.7	93.2	92.8	92.3	91.9	91.5	91.0	90.6	90.1	89.7
82	94.6	94.2	93.7	93.3	92.9	92.5	92.0	91.6	91.1	90.7
83	95.5	95.1	94.7	94.3	93.9	93.5	93.0	92.6	92.1	91.7
84	96.4	96.0	95.6	95.2	94.8	94.4	94.0	93.5	93.1	92.7
85	97.4	97.0	96.5	96.1	95.7	95.3	94.9	94.5	94.1	93.7
86	98.3	97.9	97.5	97.1	96.7	96.3	95.9	95.4	95.0	94.6
87	99.3	98.9	98.4	98.0	97.6	97.2	96.8	96.4	96.0	95.6
88	100.3	99.9	99.4	99.0	98.6	98.2	97.8	97.3	96.9	96.5
89	101.2	100.8	100.3	99.9	99.5	99.1	98.7	98.3	97.9	97.5
90	102.1	101.7	101.3	100.9	100.5	100.1	99.7	99.2	98.8	98.4
91	103.1	102.7	102.2	101.8	101.4	101.0	100.6	100.2	99.8	99.4
92	104.0	103.6	103.2	102.8	102.4	102.0	101.6	101.1	100.7	100.3
93	105.0	104.6	104.1	103.7	103.3	102.9	102.5	102.1	101.7	101.3
94	105.9	105.5	105.1	104.7	104.3	103.9	103.5	103.1	102.7	102.3
95	106.8	106.4	106.1	105.7	105.3	104.9	104.5	104.0	103.6	103.2
96	107.7	107.3	107.0	106.6	106.2	105.8	105.4	105.0	104.6	104.2
97	108.7	108.3	108.0	107.6	107.2	106.8	106.4	106.0	105.6	105.2
98	109.6	109.2	108.9	108.5	108.1	107.7	107.3	107.0	106.6	106.2
99	110.6	110.2	109.8	109.4	109.0	108.6	108.2	107.9	107.5	107.1
100	111.5	111.1	110.8	110.4	110.0	109.6	109.2	108.9	108.5	108.1
101	112.4	112.0	111.7	111.3	110.9	110.5	110.1	109.8	109.4	109.0
102	113.4	113.0	112.7	112.3	111.9	111.5	111.1	110.8	110.4	110.0
103	114.3	114.0	113.6	113.3	112.9	112.5	112.1	111.7	111.3	110.9
104	115.3	114.9	114.6	114.2	113.8	113.4	113.0	112.7	112.3	111.9
105	116.3	115.9	115.6	115.2	114.8	114.4	114.0	113.7	113.3	112.9
106	117.2	116.8	116.5	116.1	115.7	115.3	114.9	114.6	114.2	113.8
107	118.2	117.8	117.5	117.1	116.7	116.3	115.9	115.6	115.2	114.8
108	119.1	118.8	118.4	118.1	117.7	117.3	116.9	116.6	116.2	115.8
109	120.1	119.8	119.4	119.1	118.7	118.3	117.9	117.6	117.2	116.8
110	121.0	120.7	120.3	120.0	119.6	119.2	118.9	118.5	118.2	117.8
111	122.0	121.7	121.3	121.0	120.6	120.2	119.8	119.5	119.1	118.7
112	123.0	122.6	122.3	121.9	121.5	121.1	120.8	120.4	120.1	119.7
113	124.0	123.6	123.3	122.9	122.5	122.1	121.8	121.4	121.1	120.7
114	124.9	124.6	124.2	123.9	123.5	123.1	122.7	122.4	122.0	121.6
115	125.9	125.6	125.2	124.9	124.5	124.1	123.7	123.4	123.0	122.6
116	126.9	126.5	126.2	125.8	125.4	125.0	124.7	124.3	124.0	123.6
117	127.8	127.5	127.1	126.8	126.4	126.0	125.7	125.3	125.0	124.6
118	128.8	128.5	128.1	127.8	127.4	127.0	126.7	126.3	126.0	125.6
119	129.8	129.4	129.1	128.7	128.3	127.9	127.6	127.2	126.9	126.5
120	130.8	130.4	130.1	129.7	129.3	128.9	128.6	128.2	127.9	127.5
121	131.7	131.4	131.0	130.7	130.3	129.9	129.6	129.2	128.9	128.5
122	132.7	132.4	132.0	131.7	131.3	130.9	130.6	130.2	129.9	129.5
123	133.7	133.4	133.0	132.7	132.3	131.9	131.6	131.2	130.9	130.5
124	134.7	134.4	134.0	133.7	133.3	132.9	132.6	132.2	131.9	131.5
125	135.7	135.3	135.0	134.6	134.3	133.9	133.6	133.2	132.9	132.5
126	136.6	136.2	135.9	135.5	135.2	134.9	134.5	134.2	133.8	133.5
127	137.5	137.2	136.8	136.5	136.1	135.8	135.4	135.1	134.7	134.4
128	138.5	138.1	137.8	137.4	137.1	136.8	136.4	136.1	135.7	135.4
129	139.5	139.1	138.8	138.4	138.1	137.7	137.4	137.0	136.7	136.3
130	140.4	140.0	139.7	139.3	139.0	138.7	138.3	138.0	137.6	137.3

TRUE PER CENT.

Ind. 131 to 195. Temp. 31° to 40°.

Indication.	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°
	TEMPERATURES.									
131	141.4	141.0	140.7	140.3	140.0	139.6	139.3	138.9	138.6	138.2
132	142.3	141.9	141.6	141.2	140.9	140.6	140.2	139.9	139.5	139.2
133	143.3	142.9	142.6	142.2	141.9	141.6	141.2	140.9	140.5	140.2
134	144.2	143.9	143.5	143.2	142.8	142.5	142.1	141.8	141.4	141.1
135	145.2	144.8	144.5	144.1	143.8	143.5	143.1	142.8	142.4	142.1
136	146.2	145.8	145.5	145.1	144.8	144.5	144.1	143.8	143.4	143.1
137	147.1	146.8	146.4	146.1	145.8	145.4	145.1	144.7	144.4	144.0
138	148.1	147.7	147.4	147.0	146.7	146.4	146.0	145.7	145.3	145.0
139	149.0	148.7	148.3	148.0	147.7	147.4	147.0	146.7	146.3	146.0
140	150.0	149.7	149.3	149.0	148.7	148.4	148.0	147.7	147.3	147.0
141	151.0	150.6	150.3	149.9	149.6	149.3	149.0	148.6	148.3	148.0
142	152.0	151.6	151.3	150.9	150.6	150.3	149.9	149.6	149.2	148.9
143	152.9	152.5	152.2	151.8	151.5	151.2	150.9	150.5	150.2	149.9
144	153.9	153.5	153.2	152.8	152.5	152.2	151.9	151.5	151.2	150.9
145	154.8	154.5	154.1	153.8	153.5	153.2	152.9	152.5	152.2	151.9
146	155.8	155.5	155.1	154.8	154.5	154.2	153.8	153.5	153.1	152.8
147	156.8	156.4	156.1	155.7	155.4	155.1	154.8	154.4	154.1	153.8
148	157.7	157.4	157.0	156.7	156.4	156.1	155.8	155.4	155.1	154.8
149	158.7	158.4	158.0	157.7	157.4	157.1	156.7	156.4	156.0	155.7
150	159.6	159.3	158.9	158.6	158.3	158.0	157.7	157.3	157.0	156.7
151	160.6	160.3	159.9	159.6	159.3	159.0	158.7	158.3	158.0	157.7
152	161.6	161.3	160.9	160.6	160.3	160.0	159.7	159.3	159.0	158.7
153	162.5	162.2	161.8	161.5	161.2	160.9	160.6	160.2	159.9	159.6
154	163.5	163.2	162.8	162.5	162.2	161.9	161.6	161.2	160.9	160.6
155	164.5	164.2	163.8	163.5	163.2	162.9	162.6	162.2	161.9	161.6
156	165.4	165.1	164.7	164.4	164.1	163.8	163.5	163.2	162.9	162.6
157	166.4	166.1	165.7	165.4	165.1	164.8	164.5	164.1	163.8	163.5
158	167.4	167.1	166.7	166.4	166.1	165.8	165.5	165.1	164.8	164.5
159	168.3	168.0	167.6	167.3	167.0	166.7	166.4	166.1	165.8	165.5
160	169.2	168.9	168.6	168.3	168.0	167.7	167.4	167.0	166.7	166.4
161	170.1	169.8	169.5	169.2	168.9	168.6	168.3	168.0	167.7	167.4
162	171.1	170.8	170.5	170.2	169.9	169.6	169.3	169.0	168.7	168.4
163	172.0	171.7	171.4	171.1	170.8	170.5	170.2	169.9	169.6	169.3
164	172.9	172.6	172.4	172.1	171.8	171.5	171.2	170.9	170.6	170.3
165	173.8	173.5	173.3	173.0	172.7	172.4	172.1	171.9	171.6	171.3
166	174.8	174.5	174.3	174.0	173.7	173.4	173.1	172.8	172.5	172.2
167	175.7	175.4	175.2	174.9	174.6	174.3	174.0	173.8	173.5	173.2
168	176.6	176.3	176.1	175.8	175.5	175.2	174.9	174.7	174.4	174.1
169	177.6	177.3	177.1	176.8	176.5	176.2	175.9	175.6	175.3	175.0
170	178.5	178.2	178.0	177.7	177.4	177.1	176.8	176.6	176.3	176.0
171	179.4	179.1	178.9	178.6	178.3	178.0	177.7	177.5	177.2	176.9
172	180.3	180.0	179.8	179.5	179.2	178.9	178.7	178.4	178.2	177.9
173	181.2	181.0	180.7	180.5	180.2	179.9	179.6	179.4	179.1	178.8
174	182.1	181.9	181.6	181.4	181.1	180.8	180.5	180.3	180.0	179.7
175	183.0	182.8	182.5	182.3	182.0	181.7	181.5	181.2	181.0	180.7
176	183.9	183.7	183.4	183.2	182.9	182.6	182.4	182.1	181.9	181.6
177	184.9	184.7	184.4	184.2	183.9	183.6	183.3	183.1	182.8	182.5
178	185.8	185.6	185.3	185.1	184.8	184.5	184.3	184.0	183.8	183.5
179	186.7	186.5	186.2	186.0	185.7	185.4	185.2	184.9	184.7	184.4
180	187.6	187.3	187.1	186.8	186.6	186.4	186.1	185.9	185.6	185.4
181	188.5	188.2	188.0	187.7	187.5	187.3	187.1	186.8	186.6	186.4
182	189.4	189.1	188.9	188.6	188.4	188.2	188.0	187.7	187.5	187.3
183	190.3	190.0	189.8	189.5	189.3	189.1	188.9	188.6	188.4	188.2
184	191.1	190.9	190.6	190.4	190.2	190.0	189.7	189.5	189.2	189.0
185	192.0	191.8	191.5	191.3	191.1	190.9	190.6	190.4	190.1	189.9
186	192.8	192.6	192.3	192.1	191.9	191.7	191.5	191.2	191.0	190.8
187	193.7	193.5	193.2	193.0	192.8	192.6	192.4	192.1	191.9	191.7
188	194.6	194.4	194.1	193.9	193.7	193.5	193.3	193.1	192.9	192.7
189	195.4	195.2	195.0	194.8	194.6	194.4	194.2	194.0	193.8	193.6
190	196.3	196.1	195.9	195.7	195.5	195.3	195.1	194.9	194.7	194.5
191	197.2	197.0	196.8	186.6	196.4	196.2	196.0	195.8	195.6	195.4
192	198.1	197.9	197.8	197.6	197.4	197.2	197.0	196.7	196.5	196.3
193	199.0	198.8	198.7	198.5	198.3	198.1	197.9	197.7	197.5	197.3
194	200.0	199.8	199.6	199.4	199.2	199.0	198.8	198.6	198.4	198.2
195	....	....	....	....	....	199.9	199.7	199.6	199.4	199.2

—TRUE PER CENT.

Ind 1 to 65. Temp. 41° to 50°.

Indication.	TEMPERATURES.									
	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°
1	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8
2	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8
3	4.0	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.8	3.8
4	5.0	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.8	4.8
5	6.0	6.0	6.0	6.0	6.0	6.0	5.9	5.9	5.8	5.8
6	7.0	7.0	7.0	7.0	7.0	7.0	6.9	6.9	6.8	6.8
7	8.0	8.0	8.0	8.0	8.0	8.0	7.9	7.9	7.8	7.8
8	9.0	9.0	9.0	9.0	9.0	9.0	8.9	8.9	8.8	8.8
9	10.1	10.1	10.0	10.0	10.0	10.0	9.9	9.9	9.8	9.8
10	11.2	11.2	11.1	11.1	11.1	11.1	11.0	11.0	10.9	10.9
11	12.3	12.3	12.2	12.2	12.2	12.2	12.1	12.1	12.0	12.0
12	13.3	13.3	13.3	13.3	13.3	13.2	13.2	13.1	13.1	13.0
13	14.4	14.4	14.3	14.3	14.3	14.2	14.2	14.1	14.1	14.0
14	15.5	15.5	15.4	15.4	15.4	15.3	15.3	15.2	15.2	15.1
15	16.6	16.5	16.5	16.4	16.4	16.3	16.3	16.2	16.2	16.1
16	17.7	17.6	17.6	17.5	17.5	17.4	17.3	17.3	17.2	17.1
17	18.7	18.6	18.6	18.5	18.5	18.4	18.4	18.3	18.3	18.2
18	19.7	19.7	19.6	19.6	19.5	19.4	19.4	19.3	19.3	19.2
19	20.9	20.9	20.8	20.8	20.7	20.6	20.5	20.5	20.4	20.3
20	22.2	22.1	22.1	22.0	21.9	21.8	21.7	21.6	21.5	21.4
21	23.3	23.2	23.2	23.1	23.0	22.9	22.8	22.7	22.6	22.6
22	24.4	24.3	24.3	24.2	24.1	24.0	23.9	23.7	23.6	23.5
23	25.5	25.4	25.4	25.3	25.2	25.1	25.0	24.8	24.7	24.6
24	26.7	26.6	26.5	26.4	26.3	26.2	26.1	25.9	25.8	25.7
25	27.8	27.7	27.6	27.5	27.4	27.3	27.1	27.0	26.8	26.7
26	29.0	28.9	28.7	28.6	28.5	28.4	28.2	28.1	27.9	27.8
27	30.3	30.1	30.0	29.8	29.7	29.5	29.4	29.2	29.1	28.9
28	31.4	31.3	31.1	31.0	30.8	30.6	30.5	30.3	30.2	30.0
29	32.7	32.6	32.4	32.3	32.1	31.9	31.7	31.5	31.3	31.1
30	33.9	33.7	33.6	33.4	33.2	33.0	32.8	32.6	32.4	32.2
31	35.1	34.9	34.8	34.6	34.4	34.2	34.0	33.7	33.5	33.3
32	36.3	36.1	35.9	35.7	35.5	35.3	35.1	34.8	34.6	34.4
33	37.6	37.4	37.1	36.9	36.7	36.5	36.2	36.0	35.7	35.5
34	38.9	38.6	38.4	38.1	37.9	37.6	37.4	37.1	36.9	36.6
35	40.2	39.9	39.7	39.4	39.1	38.8	38.5	38.3	38.0	37.7
36	41.5	41.2	40.9	40.6	40.3	40.0	39.7	39.5	39.2	38.9
37	42.8	42.5	42.1	41.8	41.5	41.2	40.9	40.6	40.3	40.0
38	44.1	43.7	43.4	43.0	42.7	42.4	42.1	41.7	41.4	41.1
39	45.3	44.9	44.6	44.2	43.9	43.6	43.3	42.9	42.6	42.3
40	46.5	46.1	45.8	45.4	45.1	44.8	44.4	44.1	43.7	43.4
41	47.6	47.3	46.9	46.6	46.2	45.9	45.5	45.2	44.8	44.5
42	48.8	48.4	48.1	47.7	47.4	47.0	46.7	46.3	46.0	45.6
43	49.9	49.6	49.2	48.9	48.5	48.1	47.7	47.4	47.0	46.6
44	51.1	50.7	50.4	50.0	49.6	49.2	48.8	48.5	48.1	47.7
45	52.4	52.0	51.5	51.1	50.7	50.3	49.9	49.6	49.2	48.8
46	53.6	53.2	52.7	52.3	51.9	51.5	51.1	50.7	50.3	49.9
47	54.8	54.3	53.9	53.4	53.0	52.6	52.2	51.7	51.3	50.9
48	55.9	55.5	55.0	54.6	54.1	53.7	53.3	52.8	52.4	52.0
49	57.1	56.6	56.2	55.7	55.3	54.9	54.4	54.0	53.5	53.1
50	58.2	57.7	57.3	56.8	56.4	56.0	55.5	55.1	54.6	54.2
51	59.3	58.9	58.4	58.0	57.5	57.1	56.6	56.2	55.7	55.3
52	60.4	60.0	59.5	59.1	58.6	58.2	57.7	57.3	56.8	56.4
53	61.6	61.1	60.7	60.2	59.7	59.2	58.8	58.3	57.9	57.4
54	62.6	62.2	61.7	61.3	60.8	60.3	59.9	59.4	59.0	58.5
55	63.7	63.2	62.8	62.3	61.8	61.3	60.9	60.4	60.0	59.5
56	64.7	64.2	63.8	63.3	62.8	62.3	61.9	61.4	61.0	60.5
57	65.8	65.3	64.9	64.4	63.9	63.4	63.0	62.5	62.1	61.6
58	66.8	66.3	65.9	65.4	64.9	64.4	64.0	63.5	63.1	62.6
59	67.8	67.3	66.9	66.4	65.9	65.4	65.0	64.5	64.1	63.6
60	68.8	68.4	67.9	67.5	67.0	66.5	66.0	65.6	65.1	64.6
61	69.9	69.4	69.0	68.5	68.0	67.5	67.0	66.6	66.1	65.6
62	70.9	70.4	70.0	69.5	69.0	68.5	68.0	67.6	67.1	66.6
63	71.9	71.4	71.0	70.5	70.0	69.5	69.0	68.6	68.1	67.6
64	72.9	72.4	72.0	71.5	71.0	70.5	70.1	69.6	69.2	68.7
65	73.9	73.4	73.0	72.5	72.0	71.5	71.1	70.6	70.2	69.7

TRUE PER CENT.

Ind. 66 to 130. Temp. 41° to 50°.

Indication.	TEMPERATURES.									
	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°
66	75.0	74.5	74.0	73.5	73.0	72 5	72.1	71.6	71.2	70.7
67	76.0	75.5	75.0	74.5	74.0	73 5	73.1	72.6	72.2	71 7
68	76.9	76.5	76.0	75.6	75.1	74.6	74.1	73.7	73 2	72 7
69	77.9	77.4	77.0	76.5	76.1	75.6	75.1	74.7	74.2	73 7
70	78.9	78.4	78.0	77.5	77.1	76.6	76.1	75.7	75.2	74 7
71	79.8	79.4	78.9	78.5	78.0	77.5	77 1	76.6	76.2	75 7
72	80.8	80.3	79.9	79.4	79.0	78 5	78·1	77.6	77 2	76 7
73	81.7	81.3	80.8	80.4	80.0	79.5	79.1	78.6	78.2	77.7
74	82.7	82 2	81.8	81.3	80.9	80.4	80.0	79 5	79.1	78 6
75	83.6	83.2	82.7	82.3	81.8	81.4	80.9	80.5	80.0	79 6
76	84.6	84.1	83.7	83.2	82.8	82.4	81.9	81.5	81.0	80 6
77	85.5	85.0	84.6	84.1	83.7	83 3	82.8	82.4	81.9	81 5
78	86.5	86.0	85.6	85.1	84.7	84 3	83 8	83.4	82.9	82 5
79	87.5	87.0	86 6	86.1	85.7	85.3	84 8	84.4	83.9	83.5
80	88.4	88.0	87.5	87 1	86.7	86.2	85.8	85.3	84.9	84.4
81	89.3	88.9	88.4	88 0	87.6	87.2	86.7	86.3	85.8	85 4
82	90.3	89 9	89 4	89.0	88.6	88 2	87 7	87.3	86.8	86 4
83	91.3	90 9	90.4	90.0	89.6	89.2	88 7	88.3	87.8	87 4
84	92.3	91 9	91.4	91.0	90 6	90.2	89.7	89.3	88.8	88 4
85	93.3	92.8	92.4	91.9	91.5	91.1	90.7	90.2	89.8	89.4
86	94.2	93.8	93.3	92.9	92.5	92.1	91.7	91.2	90 8	90.4
87	95.2	94 8	94.3	93.9	93.5	93.1	92.7	92.2	91.8	91 4
88	96.1	95.7	95.3	94 9	94.5	94.1	93.6	93.2	92.7	92 3
89	97.1	96.7	96.2	95.8	95.4	95.0	94.6	94.1	93.7	93 3
90	98.0	97 6	97.2	96 8	96.4	96.0	95.6	95.1	94.7	94.3
91	99.0	98.6	98.1	97.7	97.3	96.9	96.5	96.1	95.7	95 3
92	99.9	99.5	99.1	98.7	98 3	97.9	97.5	97.0	96.6	96 2
93	100.9	100.5	100.1	99.7	99.3	98.9	98.5	98.0	97.6	97 2
94	101.9	101.5	101.1	100.7	100.3	99.9	99.5	99.0	98.6	98.2
95	102.8	102.4	102.0	101.6	101.2	100.8	100.4	100.0	99.6	99.2
96	103.8	103.4	103.0	102.6	102.2	101.8	101.4	101.0	100.6	100.2
97	104.8	104.4	104.0	103.6	103.2	102.8	102 4	102.0	101.6	101.2
98	105.8	105.4	105.0	104.6	104.2	103.8	103.4	103.0	102.6	102 2
99	106.7	106.3	105.9	105.5	105.1	104.7	104 3	103 9	103.5	103 1
100	107.7	107.3	106.9	106.5	106.1	105.7	105.3	104.9	104.5	104 1
101	108.6	108.2	107.9	107.5	107.1	106.7	106.3	105.9	105.5	105 1
102	109.6	109 2	108.8	108.4	108.0	107.6	107.2	106.8	106.4	106 0
103	110.5	110.1	109.8	109.4	109.0	108.6	108.2	107.8	107 4	107 0
104	111.5	111.1	110.8	110.4	110.0	109.6	109.2	108.8	108 4	108 0
105	112.5	112 1	111.8	111.4	111.0	110.6	110.2	109.8	109.4	109.0
106	113.4	113.0	112.7	112.3	111.9	111.5	111.1	110.8	110.4	110 0
107	114.4	114.0	113.7	113.3	112.9	112.5	112 1	111 8	111.4	111.0
108	115.4	115 0	114.7	114.3	113.9	113.5	113.1	112.8	112.4	112.0
109	116.4	116.0	115.7	115.3	114.9	114.5	114.1	113.8	113.4	113.0
110	117.4	117.0	116.6	116.2	115.8	115.4	115.0	114.7	114.3	113.9
111	118.3	117 9	117.6	117.2	116.8	116.4	116.0	115.7	115.3	114 9
112	119.3	118.9	118.6	118.2	117 8	117.4	117 0	116.7	116.3	115 9
113	120.3	119 9	119.6	119.2	118 8	118.4	118.0	117.7	117.3	116 9
114	121.2	120.8	120.5	120.1	119.7	119.3	119.0	118.6	118 3	117 9
115	122.2	121.8	121.5	121.1	120.7	120.3	120.0	119.6	119.3	118 9
116	123.2	122 8	122.5	122.1	121.7	121.3	121 0	120.6	120.3	119 9
117	124.2	123 8	123.5	123.1	122.7	122 3	121.9	121 6	121 2	120 8
118	125.2	124 8	124.5	124.1	123.7	123 3	122.9	122.6	122.2	121 8
119	126.1	125.8	125.4	125.1	124.7	124.3	123.9	123.6	123.2	122 8
120	127.1	126 8	126.4	126.1	125.7	125.3	124.9	124.6	124.2	123 8
121	128.1	127 8	127 4	127.1	126.7	126.3	125.9	125.6	125.2	124 8
122	129.1	128.8	128.4	128.1	127.7	127.3	126.9	126.6	126.2	125.8
123	130 1	129.8	129.4	129.1	128.7	128.3	127 9	127.6	127.2	126 8
124	131.1	130 7	130.4	130.0	129.6	129.2	128 9	128.5	128.2	127 8
125	132 1	131.7	131.4	131.0	130.6	130.2	129.9	129.5	129.2	128 8
126	133 1	132.7	132.4	132.0	131.6	131.2	130.9	130 5	130.2	129 8
127	134.0	133 7	133.3	133.0	132 6	132.2	131.9	131.5	131.2	130 8
128	135.0	134.7	134.3	134.0	133.6	133.2	132.9	132.5	132.2	131 8
129	135.9	135.6	135.2	134.9	134.5	134.1	133.8	133.4	133 1	132 7
130	136.9	136.6	136.2	135.9	135.5	135.1	134.8	134 4	134.1	133 7

TRUE PER CENT.

Ind. 131 to 197. Temp. 41° to 50°.

Indication.	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°
	TEMPERATURES.									
131	137.9	137.5	137.2	136.8	136.5	136.1	135.8	135.4	135.1	134.7
132	138.9	138.5	138.2	137.8	137.5	137.1	136.8	136.4	136.1	135.7
133	139.8	139.5	139.1	138.8	138.4	138.1	137.7	137.4	137.0	136.7
134	140.8	140.4	140.1	139.7	139.4	139.0	138.7	138.3	138.0	137.6
135	141.8	141.4	141.1	140.7	140.4	140.0	139.7	139.3	139.0	138.6
136	142.7	142.4	142.0	141.7	141.3	141.0	140.6	140.3	139.9	139.6
137	143.7	143.3	143.0	142.6	142.3	141.9	141.6	141.2	140.9	140.5
138	144.7	144.3	144.0	143.6	143.3	142.9	142.6	142.2	141.9	141.5
139	145.7	145.3	145.0	144.6	144.3	143.9	143.6	143.2	142.9	142.5
140	146.7	146.3	146.0	145.6	145.3	144.9	144.6	144.2	143.9	143.5
141	147.7	147.3	147.0	146.6	146.3	145.9	145.6	145.2	144.9	144.5
142	148.6	148.3	147.9	147.6	147.3	146.9	146.6	146.2	145.9	145.5
143	149.6	149.2	148.9	148.5	148.2	147.9	147.5	147.2	146.8	146.5
144	150.6	150.2	149.9	149.5	149.2	148.9	148.5	148.2	147.8	147.5
145	151.6	151.2	150.9	150.5	150.2	149.9	149.5	149.2	148.8	148.5
146	152.5	152.1	151.8	151.4	151.1	150.8	150.5	150.1	149.8	149.5
147	153.5	153.1	152.8	152.4	152.1	151.8	151.4	151.1	150.7	150.4
148	154.5	154.1	153.8	153.4	153.1	152.8	152.4	152.1	151.7	151.4
149	155.4	155.1	154.7	154.4	154.1	153.8	153.4	153.1	152.7	152.4
150	156.4	156.1	155.7	155.4	155.1	154.8	154.4	154.1	153.7	153.4
151	157.4	157.1	156.7	156.4	156.1	155.8	155.4	155.1	154.7	154.4
152	158.4	158.0	157.7	157.3	157.0	156.7	156.4	156.0	155.7	155.4
153	159.3	159.0	158.6	158.3	158.0	157.7	157.4	157.0	156.7	156.4
154	160.3	160.0	159.6	159.3	159.0	158.7	158.3	158.0	157.6	157.3
155	161.3	161.0	160.6	160.3	160.0	159.7	159.3	159.0	158.6	158.3
156	162.3	161.9	161.6	161.2	160.9	160.6	160.3	159.9	159.6	159.3
157	163.2	162.9	162.5	162.2	161.9	161.6	161.3	160.9	160.6	160.3
158	164.2	163.9	163.5	163.2	162.9	162.6	162.3	161.9	161.6	161.3
159	165.2	164.9	164.5	164.2	163.9	163.6	163.3	162.9	162.6	162.3
160	166.1	165.8	165.4	165.1	164.8	164.5	164.2	163.8	163.5	163.2
161	167.1	166.8	166.4	166.1	165.8	165.5	165.2	164.8	164.5	164.2
162	168.1	167.8	167.4	167.1	166.8	166.5	166.2	165.8	165.5	165.2
163	169.0	168.7	168.4	168.1	167.8	167.5	167.2	166.8	166.5	166.2
164	170.0	169.7	169.3	169.0	168.7	168.4	168.1	167.8	167.5	167.2
165	171.0	170.7	170.3	170.0	169.7	169.4	169.1	168.8	168.5	168.2
166	171.9	171.6	171.3	171.0	170.7	170.4	170.1	169.8	169.5	169.2
167	172.9	172.6	172.3	172.0	171.7	171.4	171.1	170.7	170.4	170.1
168	173.8	173.5	173.2	172.9	172.6	172.3	172.0	171.7	171.4	171.1
169	174.7	174.4	174.2	173.9	173.6	173.3	173.0	172.7	172.4	172.1
170	175.7	175.4	175.1	174.8	174.5	174.2	173.9	173.7	173.4	173.1
171	176.6	176.3	176.1	175.8	175.5	175.2	174.9	174.7	174.4	174.1
172	177.6	177.3	177.0	176.7	176.4	176.1	175.8	175.6	175.3	175.0
173	178.5	178.2	178.0	177.7	177.4	177.1	176.8	176.5	176.2	175.9
174	179.4	179.1	178.9	178.6	178.3	178.0	177.7	177.5	177.2	176.9
175	180.4	180.1	179.9	179.6	179.3	179.0	178.7	178.5	178.2	177.9
176	181.3	181.1	180.8	180.6	180.3	180.0	179.7	179.5	179.2	178.9
177	182.2	182.0	181.7	181.5	181.2	180.9	180.7	180.4	180.2	179.9
178	183.2	182.9	182.7	182.4	182.1	181.8	181.6	181.3	181.1	180.8
179	184.1	183.9	183.6	183.4	183.1	182.8	182.5	182.3	182.0	181.7
180	185.1	184.9	184.6	184.4	184.1	183.8	183.5	183.3	183.0	182.7
181	186.1	185.9	185.6	185.4	185.1	184.8	184.5	184.3	184.0	183.7
182	187.0	186.8	186.5	186.3	186.0	185.7	185.5	185.2	185.0	184.7
183	188.0	187.7	187.5	187.2	187.0	186.7	186.5	186.2	186.0	185.7
184	188.8	188.5	188.3	188.0	187.8	187.6	187.3	187.1	186.8	186.6
185	189.7	189.5	189.2	189.0	188.8	188.6	188.3	188.1	187.8	187.6
186	190.6	190.4	190.1	189.9	189.7	189.5	189.2	189.0	188.7	188.5
187	191.5	191.3	191.0	190.8	190.6	190.4	190.1	189.9	189.6	189.4
188	192.5	192.2	192.0	191.7	191.5	191.3	191.1	190.8	190.6	190.4
189	193.4	193.2	192.9	192.7	192.5	192.3	192.0	191.8	191.5	191.3
190	194.3	194.1	193.8	193.6	193.4	193.2	193.0	192.7	192.5	192.3
191	195.2	195.0	194.8	194.6	194.4	194.2	194.0	193.7	193.5	193.3
192	196.1	195.9	195.7	195.5	195.3	195.1	194.9	194.6	194.4	194.2
193	197.1	196.9	196.7	196.5	196.3	196.1	195.9	195.6	195.4	195.2
194	198.0	197.8	197.6	197.4	197.2	197.0	196.8	196.6	196.4	196.2
195	199.0	198.8	198.6	198.4	198.2	198.0	197.8	197.5	197.3	197.1
196	199.9	199.7	199.5	199.3	199.1	198.9	198.7	198.5	198.3	198.1
197	....	....	....	....	....	199.9	199.7	199.5	199.3	199.1

TRUE PER CENT.

Ind. 1 to 65. Temp. 51° to 60°

Indication.	TEMPERATURES.									
	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°
1	1.7	1.7	1.6	1.6	1.5	1.4	1.3	1.2	1.1	1.0
2	2.7	2.7	2.6	2.6	2.5	2.4	2.3	2.2	2.1	2.0
3	3.7	3.7	3.6	3.6	3.5	3.4	3.3	3.2	3.1	3.0
4	4.7	4.7	4.6	4.6	4.5	4.4	4.3	4.2	4.1	4.0
5	5.7	5.7	5.6	5.6	5.5	5.4	5.3	5.2	5.1	5.0
6	6.7	6.7	6.6	6.6	6.5	6.4	6.3	6.2	6.1	6.0
7	7.7	7.7	7.6	7.6	7.5	7.4	7.3	7.2	7.1	7.0
8	8.7	8.7	8.6	8.6	8.5	8.4	8.3	8.2	8.1	8.0
9	9.7	9.7	9.6	9.6	9.5	9.4	9.3	9.2	9.1	9.0
10	10.8	10.7	10.7	10.6	10.5	10.4	10.3	10.2	10.1	10.0
11	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11.0
12	12.9	12.8	12.8	12.7	12.6	12.5	12.4	12.2	12.1	12.0
13	13.9	13.8	13.8	13.7	13.6	13.5	13.4	13.2	13.1	13.0
14	15.0	14.9	14.8	14.7	14.6	14.5	14.4	14.2	14.1	14.0
15	16.0	15.9	15.8	15.7	15.6	15.5	15.4	15.2	15.1	15.0
16	17.0	16.9	16.9	16.8	16.7	16.6	16.4	16.3	16.1	16.0
17	18.1	18.0	17.9	17.8	17.7	17.6	17.4	17.3	17.1	17.0
18	19.1	19.0	18.9	18.8	18.7	18.6	18.4	18.3	18.1	18.0
19	20.2	20.1	19.9	19.8	19.7	19.6	19.4	19.3	19.1	19.0
20	21.3	21.1	21.0	20.8	20.7	20.6	20.4	20.3	20.1	20.0
21	22.4	22.2	22.1	21.9	21.8	21.6	21.5	21.3	21.2	21.0
22	23.4	23.2	23.1	22.9	22.8	22.6	22.5	22.3	22.2	22.0
23	24.5	24.3	24.2	24.0	23.9	23.7	23.5	23.4	23.2	23.0
24	25.5	25.4	25.2	25.1	24.9	24.7	24.5	24.4	24.2	24.0
25	26.5	26.4	26.2	26.1	25.9	25.7	25.5	25.4	25.2	25.0
26	27.6	27.5	27.3	27.2	27.0	26.8	26.6	26.4	26.2	26.0
27	28.7	28.5	28.4	28.2	28.0	27.8	27.6	27.4	27.2	27.0
28	29.8	29.6	29.5	29.3	29.1	28.9	28.7	28.4	28.2	28.0
29	30.9	30.7	30.5	30.3	30.1	29.9	29.7	29.4	29.2	29.0
30	32.0	31.8	31.6	31.4	31.2	31.0	30.7	30.5	30.2	30.0
31	33.1	32.9	32.6	32.4	32.2	32.0	31.7	31.5	31.2	31.0
32	34.2	34.0	33.7	33.5	33.3	33.0	32.8	32.5	32.3	32.0
33	35.3	35.0	34.8	34.5	34.3	34.0	33.8	33.5	33.3	33.0
34	36.4	36.1	35.9	35.6	35.4	35.1	34.8	34.6	34.3	34.0
35	37.4	37.2	36.9	36.7	36.4	36.1	35.8	35.6	35.3	35.0
36	38.6	38.3	38.1	37.8	37.5	37.2	36.9	36.6	36.3	36.0
37	39.7	39.4	39.1	38.8	38.5	38.2	37.9	37.6	37.3	37.0
38	40.8	40.5	40.2	39.9	39.6	39.3	39.0	38.6	38.3	38.0
39	42.0	41.6	41.3	40.9	40.6	40.3	40.0	39.6	39.3	39.0
40	43.1	42.7	42.4	42.0	41.7	41.4	41.0	40.7	40.3	40.0
41	44.1	43.8	43.4	43.1	42.7	42.4	42.0	41.7	41.3	41.0
42	45.2	44.9	44.5	44.2	43.8	43.4	43.1	42.7	42.4	42.0
43	46.3	45.9	45.6	45.2	44.9	44.5	44.1	43.8	43.4	43.0
44	47.3	47.0	46.6	46.3	45.9	45.5	45.1	44.8	44.4	44.0
45	48.4	48.0	47.7	47.3	46.9	46.5	46.1	45.8	45.4	45.0
46	49.5	49.1	48.8	48.4	48.0	47.6	47.2	46.8	46.4	46.0
47	50.5	50.1	49.8	49.4	49.0	48.6	48.2	47.8	47.4	47.0
48	51.6	51.2	50.8	50.4	50.0	49.6	49.2	48.8	48.4	48.0
49	52.7	52.3	51.8	51.4	51.0	50.6	50.2	49.8	49.4	49.0
50	53.8	53.4	52.9	52.5	52.1	51.7	51.3	50.8	50.4	50.0
51	54.9	54.4	54.0	53.5	53.1	52.7	52.3	51.8	51.4	51.0
52	56.0	55.5	55.1	54.6	54.2	53.8	53.3	52.9	52.4	52.0
53	57.0	56.5	56.1	55.6	55.2	54.8	54.3	53.9	53.4	53.0
54	58.0	57.6	57.1	56.7	56.2	55.8	55.3	54.9	54.4	54.0
55	59.0	58.6	58.1	57.7	57.2	56.8	56.3	55.9	55.4	55.0
56	60.0	59.6	59.1	58.7	58.2	57.8	57.3	56.9	56.4	56.0
57	61.1	60.6	60.2	59.7	59.2	58.8	58.3	57.9	57.4	57.0
58	62.1	61.7	61.2	60.8	60.3	59.8	59.4	58.9	58.5	58.0
59	63.1	62.7	62.2	61.8	61.3	60.8	60.4	59.9	59.5	59.0
60	64.1	63.7	63.2	62.8	62.3	61.8	61.4	60.9	60.5	60.0
61	65.1	64.7	64.2	63.8	63.3	62.8	62.4	61.9	61.5	61.0
62	66.1	65.7	65.2	64.8	64.3	63.8	63.4	62.9	62.5	62.0
63	67.1	66.7	66.2	65.8	65.3	64.8	64.4	63.9	63.5	63.0
64	68.2	67.7	67.3	66.8	66.3	65.8	65.4	64.9	64.5	64.0
65	69.2	68.7	68.3	67.8	67.3	66.8	66.4	65.9	65.5	65.0

TRUE PER CENT.

Ind. 66 to 130. Temp. 51° to 60°

Indication.	Temperatures.									
	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°
66	70.2	69.7	69.3	68.8	68.3	67.8	67.4	66.9	66.5	66.0
67	71.2	70.7	70.3	69.8	69.3	68.8	68.4	67.9	67.5	67.0
68	72.2	71.7	71.3	70.8	70.3	69.8	69.4	68.9	68.5	68.0
69	73.2	72.7	72.3	71.8	71.3	70.8	70.4	69.9	69.5	69.0
70	74.2	73.7	73.3	72.8	72.3	71.8	71.4	70.9	70.5	70.0
71	75.2	74.7	74.3	73.8	73.3	72.8	72.4	71.9	71.5	71.0
72	76.2	75.7	75.3	74.8	74.3	73.8	73.4	72.9	72.5	72.0
73	77.2	76.7	76.3	75.8	75.3	74.8	74.4	73.9	73.5	73.0
74	78.1	77.7	77.2	76.8	76.3	75.8	75.4	74.9	74.5	74.0
75	79.1	78.7	78.2	77.8	77.3	76.8	76.4	75.9	75.5	75.0
76	80.1	79.7	79.2	78.8	78.3	77.8	77.4	76.9	76.5	76.0
77	81.1	80.6	80.2	79.7	79.3	78.8	78.4	77.9	77.5	77.0
78	82.1	81.6	81.2	80.7	80.3	79.8	79.4	78.9	78.5	78.0
79	83.1	82.6	82.2	81.7	81.3	80.8	80.4	79.9	79.5	79.0
80	84.0	83.6	83.1	82.7	82.3	81.8	81.4	80.9	80.5	80.0
81	85.0	84.6	84.1	83.7	83.3	82.8	82.4	81.9	81.5	81.0
82	86.0	85.5	85.1	84.6	84.2	83.8	83.3	82.9	82.4	82.0
83	87.0	86.5	86.1	85.6	85.2	84.8	84.3	83.9	83.4	83.0
84	88.0	87.5	87.1	86.6	86.2	85.8	85.3	84.9	84.4	84.0
85	89.0	88.5	88.1	87.6	87.2	86.8	86.3	85.9	85.4	85.0
86	90.0	89.5	89.1	88.6	88.2	87.8	87.3	86.9	86.4	86.0
87	91.0	90.5	90.1	89.6	89.2	88.8	88.3	87.9	87.4	87.0
88	91.9	91.5	91.0	90.6	90.2	89.8	89.3	88.9	88.4	88.0
89	92.9	92.5	92.0	91.6	91.2	90.8	90.3	89.9	89.4	89.0
90	93.9	93.4	93.0	92.5	92.1	91.7	91.3	90.8	90.4	90.0
91	94.9	94.4	94.0	93.5	93.1	92.7	92.3	91.8	91.4	91.0
92	95.8	95.4	94.9	94.5	94.1	93.7	93.3	92.8	92.4	92.0
93	96.8	96.4	95.9	95.5	95.1	94.7	94.3	93.8	93.4	93.0
94	97.8	97.4	96.9	96.5	96.1	95.7	95.3	94.8	94.4	94.0
95	98.8	98.4	97.9	97.5	97.1	96.7	96.3	95.8	95.4	95.0
96	99.8	99.4	98.9	98.5	98.1	97.7	97.3	96.8	96.4	96.0
97	100.8	100.4	99.9	99.5	99.1	98.7	98.3	97.8	97.4	97.0
98	101.8	101.4	100.9	100.5	100.1	99.7	99.3	98.8	98.4	98.0
99	102.7	102.3	101.9	101.5	101.1	100.7	100.3	99.8	99.4	99.0
100	103.7	103.3	102.9	102.5	102.1	101.7	101.3	100.8	100.4	100.0
101	104.7	104.3	103.9	103.5	103.1	102.7	102.3	101.8	101.4	101.0
102	105.6	105.2	104.8	104.4	104.0	103.6	103.2	102.8	102.4	102.0
103	106.6	106.2	105.8	105.4	105.0	104.6	104.2	103.8	103.4	103.0
104	107.6	107.2	106.8	106.4	106.0	105.6	105.2	104.8	104.4	104.0
105	108.6	108.2	107.8	107.4	107.0	106.6	106.2	105.8	105.4	105.0
106	109.6	109.2	108.8	108.4	108.0	107.6	107.2	106.8	106.4	106.0
107	110.6	110.2	109.8	109.4	109.0	108.6	108.2	107.8	107.4	107.0
108	111.6	111.2	110.8	110.4	110.0	109.6	109.2	108.8	108.4	108.0
109	112.6	112.2	111.8	111.4	111.0	110.6	110.2	109.8	109.4	109.0
110	113.5	113.1	112.8	112.4	112.0	111.6	111.2	110.8	110.4	110.0
111	114.5	114.1	113.8	113.4	113.0	112.6	112.2	111.8	111.4	111.0
112	115.5	115.1	114.8	114.4	114.0	113.6	113.2	112.8	112.4	112.0
113	116.5	116.1	115.8	115.4	115.0	114.6	114.2	113.8	113.4	113.0
114	117.5	117.1	116.7	116.3	115.9	115.5	115.1	114.8	114.4	114.0
115	118.5	118.1	117.7	117.3	116.9	116.5	116.1	115.8	115.4	115.0
116	119.5	119.1	118.7	118.3	117.9	117.5	117.1	116.8	116.4	116.0
117	120.4	120.0	119.7	119.3	118.9	118.5	118.1	117.8	117.4	117.0
118	121.4	121.0	120.7	120.3	119.9	119.5	119.1	118.8	118.4	118.0
119	122.4	122.0	121.7	121.3	120.9	120.5	120.1	119.8	119.4	119.0
120	123.4	123.0	122.7	122.3	121.9	121.5	121.1	120.8	120.4	120.0
121	124.4	124.0	123.7	123.3	122.9	122.5	122.1	121.8	121.4	121.0
122	125.4	125.0	124.7	124.3	123.9	123.5	123.1	122.8	122.4	122.0
123	126.4	126.0	125.7	125.3	124.9	124.5	124.1	123.8	123.4	123.0
124	127.4	127.0	126.7	126.3	125.9	125.5	125.1	124.8	124.4	124.0
125	128.4	128.0	127.7	127.3	126.9	126.5	126.1	125.8	125.4	125.0
126	129.4	129.0	128.7	128.3	127.9	127.5	127.1	126.8	126.4	126.0
127	130.4	130.0	129.7	129.3	128.9	128.5	128.1	127.8	127.4	127.0
128	131.4	131.0	130.7	130.3	129.9	129.5	129.1	128.8	128.4	128.0
129	132.3	132.0	131.6	131.3	130.9	130.5	130.1	129.8	129.4	129.0
130	133.3	132.9	132.6	132.2	131.8	131.4	131.1	130.7	130.4	130.0

TRUE PER CENT.

Ind. 131 to 200 | Temp. 51° to 60°

Indication.	TEMPERATURES.									
	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°
131	134.3	133.9	133.6	133.2	132.8	132.4	132.1	131.7	131.4	131.0
132	135.3	134.9	134.6	134.2	133.8	133.4	133.1	132.7	132.4	132.0
133	136.3	135.9	135.6	135.2	134.8	134.4	134.1	133.7	133.4	133.0
134	137.2	136.9	136.5	136.2	135.8	135.4	135.1	134.7	134.4	134.0
135	138.2	137.9	137.5	137.2	136.8	136.4	136.1	135.7	135.4	135.0
136	139.2	138.9	138.5	138.2	137.8	137.4	137.1	136.7	136.4	136.0
137	140.2	139.8	139.5	139.1	138.8	138.4	138.1	137.7	137.4	137.0
138	141.2	140.8	140.5	140.1	139.8	139.4	139.1	138.7	138.4	138.0
139	142.2	141.8	141.5	141.1	140.8	140.4	140.1	139.7	139.4	139.0
140	143.2	142.8	142.5	142.1	141.8	141.4	141.1	140.7	140.4	140.0
141	144.2	143.8	143.5	143.1	142.8	142.4	142.1	141.7	141.4	141.0
142	145.2	144.8	144.5	144.1	143.8	143.4	143.1	142.7	142.4	142.0
143	146.2	145.8	145.5	145.1	144.8	144.4	144.1	143.7	143.4	143.0
144	147.2	146.8	146.5	146.1	145.8	145.4	145.1	144.7	144.4	144.0
145	148.1	147.8	147.4	147.1	146.7	146.4	146.0	145.7	145.3	145.0
146	149.1	148.8	148.4	148.1	147.7	147.4	147.0	146.7	146.3	146.0
147	150.1	149.7	149.4	149.0	148.7	148.4	148.0	147.7	147.3	147.0
148	151.1	150.7	150.4	150.0	149.7	149.4	149.0	148.7	148.3	148.0
149	152.1	151.7	151.4	151.0	150.7	150.4	150.0	149.7	149.3	149.0
150	153.1	152.7	152.4	152.0	151.7	151.4	151.0	150.7	150.3	150.0
151	154.1	153.7	153.4	153.0	152.7	152.4	152.0	151.7	151.3	151.0
152	155.1	154.7	154.4	154.0	153.7	153.4	153.0	152.7	152.3	152.0
153	156.1	155.7	155.4	155.0	154.7	154.4	154.0	153.7	153.3	153.0
154	157.0	156.7	156.3	156.0	155.7	155.4	155.0	154.7	154.3	154.0
155	158.0	157.7	157.3	157.0	156.7	156.4	156.0	155.7	155.3	155.0
156	159.0	158.7	158.3	158.0	157.7	157.4	157.0	156.7	156.3	156.0
157	160.0	159.7	159.3	159.0	158.7	158.4	158.0	157.7	157.3	157.0
158	161.0	160.6	160.3	159.9	159.6	159.3	159.0	158.6	158.3	158.0
159	162.0	161.6	161.3	160.9	160.6	160.3	160.0	159.6	159.3	159.0
160	162.9	162.6	162.2	161.9	161.6	161.3	161.0	160.6	160.3	160.0
161	163.9	163.6	163.2	162.9	162.6	162.3	162.0	161.6	161.3	161.0
162	164.9	164.6	164.2	163.9	163.6	163.3	163.0	162.6	162.3	162.0
163	165.9	165.6	165.2	164.9	164.6	164.3	164.0	163.6	163.3	163.0
164	166.9	166.6	166.2	165.9	165.6	165.3	165.0	164.6	164.3	164.0
165	167.9	167.6	167.2	166.9	166.6	166.3	166.0	165.6	165.3	165.0
166	168.9	168.6	168.2	167.9	167.6	167.3	167.0	166.6	166.3	166.0
167	169.8	169.5	169.2	168.9	168.6	168.3	168.0	167.6	167.3	167.0
168	170.8	170.5	170.2	169.9	169.6	169.3	169.0	168.6	168.3	168.0
169	171.8	171.5	171.2	170.9	170.6	170.3	170.0	169.6	169.3	169.0
170	172.8	172.5	172.2	171.9	171.6	171.3	171.0	170.6	170.3	170.0
171	173.8	173.5	173.2	172.9	172.6	172.3	172.0	171.6	171.3	171.0
172	174.7	174.4	174.1	173.8	173.5	173.2	172.9	172.6	172.3	172.0
173	175.6	175.3	175.1	174.8	174.5	174.2	173.9	173.6	173.3	173.0
174	176.6	176.3	176.1	175.8	175.5	175.2	174.9	174.6	174.3	174.0
175	177.6	177.3	177.1	176.8	176.5	176.2	175.9	175.6	175.3	175.0
176	178.6	178.3	178.1	177.8	177.5	177.2	176.9	176.6	176.3	176.0
177	179.6	179.3	179.1	178.8	178.5	178.2	177.9	177.6	177.3	177.0
178	180.5	180.2	180.0	179.7	179.4	179.1	178.8	178.6	178.3	178.0
179	181.4	181.2	180.9	180.7	180.4	180.1	179.8	179.6	179.3	179.0
180	182.4	182.2	181.9	181.7	181.4	181.1	180.8	180.6	180.3	180.0
181	183.4	183.2	182.9	182.7	182.4	182.1	181.8	181.6	181.3	181.0
182	184.4	184.2	183.9	183.7	183.4	183.1	182.8	182.6	182.3	182.0
183	185.4	185.2	184.9	184.7	184.4	184.1	183.8	183.6	183.3	183.0
184	186.3	186.1	185.8	185.6	185.3	185.0	184.8	184.5	184.3	184.0
185	187.3	187.1	186.8	186.6	186.3	186.0	185.8	185.5	185.3	185.0
186	188.3	188.0	187.8	187.5	187.3	187.0	186.8	186.5	186.3	186.0
187	189.2	189.0	188.7	188.5	188.3	188.0	187.8	187.5	187.3	187.0
188	190.2	190.0	189.7	189.5	189.3	189.0	188.8	188.5	188.3	188.0
189	191.1	190.9	190.6	190.4	190.2	190.0	189.7	189.5	189.2	189.0
190	192.1	191.9	191.6	191.4	191.2	191.0	190.7	190.5	190.2	190.0
191	193.1	192.9	192.6	192.4	192.2	192.0	191.7	191.5	191.2	191.0
192	194.0	193.8	193.6	193.4	193.2	193.0	192.7	192.5	192.2	192.0
193	195.0	194.8	194.6	194.4	194.2	194.0	193.7	193.5	193.2	193.0
194	196.0	195.8	195.6	195.4	195.2	195.0	194.7	194.5	194.2	194.0
195	196.9	196.7	196.5	196.3	196.1	195.9	195.7	195.4	195.2	195.0
196	197.9	197.7	197.5	197.3	197.1	196.9	196.7	196.4	196.2	196.0
197	198.9	198.7	198.5	198.3	198.1	197.9	197.7	197.4	197.2	197.0
198	199.9	199.7	199.5	199.3	199.1	198.9	198.7	198.4	198.2	198.0
199	....	....	....	....	200.0	199.8	199.6	199.4	199.2	199.0
200	....	....	....	....	....	....	....	....	....	200.0

TRUE PER CENT.

Ind. 1 to 65. Temp. 61° to 70°.

Indication.	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
	TEMPERATURES.									
1	0.9	0.8	0.7	0.6	0.5	0.3	0.2	0.0	....	....
2	1.9	1.8	1.7	1.6	1.5	1.3	1.2	1.0	0.9	0.7
3	2.9	2.8	2.7	2.6	2.5	2.3	2.2	2.0	1.9	1.7
4	3.9	3.8	3.6	3.5	3.4	3.3	3.1	3.0	2.8	2.7
5	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0	3.8	3.7
6	5.9	5.8	5.6	5.5	5.4	5.3	5.1	5.0	4.8	4.7
7	6.9	6.8	6 6	6.5	6.4	6.3	6.1	6.0	5.8	5.7
8	7.9	7.8	7.6	7.5	7.4	7.3	7.1	7.0	6.8	6.7
9	8.9	8.8	8.6	8.5	8.4	8.3	8.1	8.0	7.8	7.7
10	9.9	9.7	9.6	9.4	9.3	9.2	9.0	8.9	8.7	8.6
11	10.9	10.7	10.6	10.4	10.3	10.2	10.0	9.9	9.7	9.6
12	11.9	11.7	11.6	11.4	11.3	11.1	11.0	10.8	10.7	10.5
13	12.9	12.7	12.6	12.4	12.3	12.1	12.0	11.8	11.7	11.5
14	13.9	13.7	13.6	13.4	13.3	13.1	12.9	12.8	12.6	12.4
15	14.9	14.7	14.6	14.4	14.3	14.1	13.9	13.8	13.6	13.4
16	15.8	15.7	15.5	15.4	15.2	15.0	14.8	14.7	14.5	14.3
17	16.8	16.7	16.5	16.4	16.2	16.0	15.8	15.7	15.5	15.3
18	17.8	17.7	17.5	17.4	17.2	17.0	16.8	16.7	16 5	16.3
19	18.8	18.7	18.5	18.4	18.2	18.0	17.8	17.6	17.4	17.2
20	19.8	19.6	19.5	19.3	19.1	18.9	18.7	18.6	18.4	18.2
21	20.8	20.6	20.4	20.2	20.0	19.8	19 6	19.5	19.3	19 1
22	21.8	21.6	21.4	21.2	21.0	20.8	20.6	20.4	20.2	20.0
23	22.8	22.6	22.4	22.2	22.0	21.8	21.6	21.3	21.1	20 9
24	23.8	23.6	23.4	23.2	23.0	22.8	22.6	22.3	22.1	21.9
25	24.8	24.6	24.4	24.2	24.0	23.8	23.5	23.3	23.0	22.8
26	25.8	25.6	25 3	25.1	24.9	24.7	24.5	24.2	24.0	23.8
27	26.8	26.6	26.3	26.1	25.9	25.7	25.4	25.2	24.9	24.7
28	27.8	27.6	27.3	27.1	26.9	26.7	26.4	26.2	25.9	25.7
29	28.8	28.5	28.3	28.0	27.8	27.6	27.3	27.1	26.8	26 6
30	29.8	29.5	29.3	29.0	28.8	28.5	28.3	28.0	27.8	27.5
31	30.7	30.5	30.2	30.0	29.7	29.4	29.2	28.9	28.7	28.4
32	31.7	31.5	31.2	31.0	30.7	30.4	30.1	29.9	29.6	29.3
33	32.7	32.5	32.2	32.0	31.7	31.4	31.1	30.8	30.5	30.2
34	33.7	33.4	33.2	32.9	32.6	32.3	32 0	31.8	31.5	31.2
35	34.7	34.4	34.2	33.9	33.6	33.3	33.0	32.7	32.4	32.1
36	35.7	35.4	35.2	34.9	34.6	34.3	34.0	33.6	33.3	33.0
37	36.7	36.4	36.1	35.8	35.5	35.2	34.9	34.6	34.3	34 0
38	37.7	37.4	37.1	36.8	36.5	36.2	35.9	35.5	35.2	34.9
39	38.7	38.4	38.0	37.7	37.4	37.1	36 8	36.4	36.1	35.8
40	39.7	39.3	39.0	38.6	38.3	38.0	37.7	37.3	37.0	36.7
41	40.7	40.3	40.0	39.6	39.3	39.0	38.6	38.3	37.9	37.6
42	41.6	41.3	40.9	40.6	40.2	39.9	39.5	39.2	38 8	38.5
43	42.6	42.3	41.9	41.6	41.2	40.8	40.5	40.1	39.8	39.4
44	43.6	43.2	42.9	42.5	42.1	41.7	41.4	41.0	40 7	40.3
45	44.6	44.2	43.9	43.5	43.1	42.7	42.3	42.0	41.6	41.2
46	45.6	45.2	44.9	44.5	44.1	43.7	43.3	42.9	42.5	42.1
47	46.6	46.2	45.8	45.4	45.0	44.6	44.2	43.8	43.4	43 0
48	47.6	47.2	46.7	46.3	45.9	45.5	45.1	44.7	44.3	43.9
49	48.6	48.2	47.7	47.3	46.9	46.5	46.1	45.7	45.3	44.9
50	49.6	49.2	48.7	48.3	47.9	47.5	47.1	46.6	46.2	45.8
51	50.6	50.2	49.7	49.3	48.9	48.5	48.1	47.6	47.2	46.8
52	51.6	51.2	50.7	50.3	49.9	49.5	49.1	48.6	48.2	47.8
53	52.6	52.2	51.7	51.3	50.9	50.5	50.1	49.6	49.2	48.8
54	53.6	53.2	52.7	52.3	51.9	51.5	51.1	50.6	50.2	49.8
55	54.6	54.1	53.7	53.2	52.8	52.4	52.0	51.5	51.1	50.7
56	55.6	55.1	54.7	54.2	53.8	53.4	53.0	52.5	52.1	51.7
57	56.6	56.1	55.7	55.2	54.8	54.4	53.9	53.5	53.0	52.6
58	57.6	57.1	56.7	56.2	55.8	55.4	54.9	54.5	54.0	53.6
59	58.6	58.1	57.7	57.2	56.8	56.3	55.9	55.4	55.0	54.5
60	59.5	59.1	58.6	58.2	57.7	57.3	56.8	56.4	55.9	55.5
61	60.5	60.1	59.6	59.2	58.7	58.3	57.8	57.4	56.9	56.5
62	61.5	61.1	60.6	60.2	59.7	59.3	58.8	58.4	57.9	57.5
63	62.5	62.1	61.6	61.2	60.7	60.3	59.8	59.4	58.9	58.5
64	63.5	63.1	62.6	62.2	61.7	61.3	60.8	60.4	59.9	59.5
65	64.5	64.1	63.6	63.2	62.7	62.3	61.8	61.4	60.9	60.5

TRUE PER CENT.

Ind. 66 to 130. Temp. 61° to 70°.

Indication.	TEMPERATURES.									
	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
66	65.5	65.1	64.6	64.2	63.7	63.3	62.8	62.4	61.9	61.5
67	66.5	66.1	65.6	65.2	64.7	64.3	63.8	63.4	62.9	62.5
68	67.5	67.1	66.6	66.2	65.7	65.3	64.8	64.4	63.9	63.5
69	68.5	68.1	67.6	67.2	66.7	66.3	65.8	65.4	64.9	64.5
70	69.5	69.1	68.6	68.2	67.7	67.3	66.8	66.4	65.9	65.5
71	70.5	70.1	69.6	69.2	68.7	68.3	67.8	67.4	66.9	66.5
72	71.5	71.1	70.6	70.2	69.7	69.3	68.8	68.4	67.9	67.5
73	72.5	72.1	71.6	71.2	70.7	70.3	69.8	69.4	68.9	68.5
74	73.5	73.1	72.6	72.2	71.7	71.3	70.8	70.4	69.9	69.5
75	74.5	74.1	73.6	73.2	72.7	72.3	71.8	71.4	70.9	70.5
76	75.5	75.1	74.6	74.2	73.7	73.3	72.8	72.4	71.9	71.5
77	76.5	76.1	75.6	75.2	74.7	74.3	73.8	73.4	72.9	72.5
78	77.5	77.1	76.6	76.2	75.7	75.3	74.8	74.4	73.9	73.5
79	78.5	78.1	77.6	77.2	76.7	76.3	75.8	75.4	74.9	74.5
80	79.5	79.1	78.6	78.2	77.7	77.3	76.8	76.4	75.9	75.5
81	80.5	80.1	79.6	79.2	78.7	78.3	77.8	77.4	76.9	76.5
82	81.6	81.1	80.7	80.2	79.8	79.3	78.9	78.4	78.0	77.5
83	82.6	82.1	81.7	81.2	80.8	80.3	79.9	79.4	79.0	78.5
84	83.6	83.1	82.7	82.2	81.8	81.3	80.9	80.4	80.0	79.5
85	84.6	84.1	83.7	83.2	82.8	82.3	81.9	81.4	81.0	80.5
86	85.6	85.1	84.7	84.2	83.8	83.4	82.9	82.5	82.0	81.6
87	86.6	86.1	85.7	85.2	84.8	84.4	83.9	83.5	83.0	82.6
88	87.6	87.1	86.7	86.2	85.8	85.4	84.9	84.5	84.0	83.6
89	88.6	88.1	87.7	87.2	86.8	86.4	85.9	85.5	85.0	84.6
90	89.6	89.1	88.7	88.2	87.8	87.4	87.0	86.5	86.1	85.7
91	90.6	90.1	89.7	89.2	88.8	88.4	88.0	87.5	87.1	86.7
92	91.6	91.1	90.7	90.2	89.8	89.4	89.0	88.5	88.1	87.7
93	92.6	92.1	91.7	91.2	90.8	90.4	90.0	89.5	89.1	88.7
94	93.6	93.1	92.7	92.2	91.8	91.4	91.0	90.5	90.1	89.7
95	94.6	94.2	93.7	93.3	92.9	92.5	92.0	91.6	91.1	90.7
96	95.6	95.2	94.7	94.3	93.9	93.5	93.0	92.6	92.1	91.7
97	96.6	96.2	95.7	95.3	94.9	94.5	94.0	93.6	93.1	92.7
98	97.6	97.2	96.7	96.3	95.9	95.5	95.1	94.6	94.2	93.8
99	98.6	98.2	97.7	97.3	96.9	96.5	96.1	95.6	95.2	94.8
100	99.6	99.2	98.7	98.3	97.9	97.5	97.1	96.6	96.2	95.8
101	100.6	100.2	99.7	99.3	98.9	98.5	98.1	97.6	97.2	96.8
102	101.6	101.2	100.7	100.3	99.9	99.5	99.1	98.6	98.2	97.8
103	102.6	102.2	101.7	101.3	100.9	100.5	100.1	99.6	99.2	98.8
104	103.6	103.2	102.8	102.4	102.0	101.6	101.2	100.7	100.3	99.9
105	104.6	104.2	103.8	103.4	103.0	102.6	102.2	101.7	101.3	100.9
106	105.6	105.2	104.8	104.4	104.0	103.6	103.2	102.7	102.3	101.9
107	106.6	106.2	105.8	105.4	105.0	104.6	104.2	103.7	103.3	102.9
108	107.6	107.2	106.8	106.4	106.0	105.6	105.2	104.7	104.3	103.9
109	108.6	108.2	107.8	107.4	107.0	106.6	106.2	105.7	105.3	104.9
110	109.6	109.2	108.8	108.4	108.0	107.6	107.2	106.7	106.3	105.9
111	110.6	110.2	109.8	109.4	109.0	108.6	108.2	107.8	107.4	107.0
112	111.6	111.2	110.8	110.4	110.0	109.6	109.2	108.8	108.4	108.0
113	112.6	112.2	111.8	111.4	111.0	110.6	110.2	109.8	109.4	109.0
114	113.6	113.2	112.8	112.4	112.0	111.6	111.2	110.8	110.4	110.0
115	114.6	114.2	113.8	113.4	113.0	112.6	112.2	111.8	111.4	111.0
116	115.6	115.2	114.8	114.4	114.0	113.6	113.2	112.8	112.4	112.0
117	116.6	116.2	115.8	115.4	115.0	114.6	114.2	113.8	113.4	113.0
118	117.6	117.2	116.8	116.4	116.0	115.6	115.2	114.9	114.5	114.1
119	118.6	118.2	117.8	117.4	117.0	116.6	116.2	115.9	115.5	115.1
120	119.6	119.2	118.8	118.4	118.0	117.6	117.2	116.9	116.5	116.1
121	120.6	120.2	119.9	119.5	119.1	118.7	118.3	117.9	117.5	117.1
122	121.6	121.2	120.9	120.5	120.1	119.7	119.3	118.9	118.5	118.1
123	122.6	122.2	121.9	121.5	121.1	120.7	120.3	119.9	119.5	119.1
124	123.6	123.2	122.9	122.5	122.1	121.7	121.3	120.9	120.5	120.1
125	124.6	124.2	123.9	123.5	123.1	122.7	122.3	121.9	121.5	121.1
126	125.6	125.2	124.9	124.5	124.1	123.7	123.3	122.9	122.5	122.1
127	126.6	126.2	125.9	125.5	125.1	124.7	124.3	123.9	123.5	123.1
128	127.6	127.2	126.9	126.5	126.1	125.7	125.3	125.0	124.6	124.2
129	128.6	128.2	127.9	127.5	127.1	126.7	126.3	126.0	125.6	125.2
130	129.6	129.2	128.9	128.5	128.1	127.7	127.3	127.0	126.6	126.2

TRUE PER CENT.

Ind. 131 to 200. **Temp. 61° to 70°.**

Indication.	TEMPERATURES.									
	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
131	130.6	130.2	129.9	129.5	129.1	128.7	128.3	128.0	127.6	127.2
132	131.6	131.2	130.9	130.5	130.1	129.7	129.3	129.0	128.6	128.2
133	132.6	132.2	131.9	131.5	131.1	130.7	130.4	130.0	129.7	129.3
134	133.6	133.2	132.9	132.5	132.1	131.7	131.4	131.0	130.7	130.3
135	134.6	134.2	133.9	133.5	133.1	132.7	132.4	132.0	131.7	131.3
136	135.6	135.2	134.9	134.5	134.1	133.7	133.4	133.0	132.7	132.3
137	136.6	136.2	135.9	135.5	135.1	134.7	134.4	134.0	133.7	133.3
138	137.6	137.3	136.9	136.6	136.2	135.8	135.4	135.1	134.7	134.3
139	138.6	138.3	137.9	137.6	137.2	136.8	136.4	136.1	135.7	135.3
140	139.6	139.3	138.9	138.6	138.2	137.8	137.5	137.1	136.8	136.4
141	140.6	140.3	139.9	139.6	139.2	138.8	138.5	138.1	137.8	137.4
142	141.6	141.3	140.9	140.6	140.2	139.8	139.5	139.1	138.8	138.4
143	142.6	142.3	141.9	141.6	141.2	140.8	140.5	140.1	139.8	139.4
144	143.7	143.3	143.0	142.6	142.3	141.9	141.5	141.2	140.8	140.4
145	144.7	144.3	144.0	143.6	143.3	142.9	142.5	142.2	141.8	141.4
146	145.7	145.3	145.0	144.6	144.3	143.9	143.5	143.2	142.8	142.4
147	146.7	146.3	146.0	145.6	145.3	144.9	144.5	144.2	143.8	143.4
148	147.7	147.3	147.0	146.6	146.3	145.9	145.5	145.2	144.8	144.4
149	148.7	148.3	148.0	147.6	147.3	146.9	146.6	146.2	145.9	145.5
150	149.7	149.3	149.0	148.6	148.3	147.9	147.6	147.2	146.9	146.5
151	150.7	150.3	150.0	149.6	149.3	148.9	148.6	148.2	147.9	147.5
152	151.7	151.3	151.0	150.6	150.3	149.9	149.6	149.2	148.9	148.5
153	152.7	152.3	152.0	151.6	151.3	150.9	150.6	150.2	149.9	149.5
154	153.7	153.3	153.0	152.6	152.3	151.9	151.6	151.2	150.9	150.5
155	154.7	154.3	154.0	153.6	153.3	152.9	152.6	152.2	151.9	151.5
156	155.7	155.3	155.0	154.6	154.3	154.0	153.6	153.3	152.9	152.6
157	156.7	156.3	156.0	155.6	155.3	155.0	154.6	154.3	153.9	153.6
158	157.7	157.3	157.0	156.6	156.3	156.0	155.6	155.3	154.9	154.6
159	158.7	158.3	158.0	157.6	157.3	157.0	156.6	156.3	155.9	155.6
160	159.7	159.3	159.0	158.6	158.3	158.0	157.7	157.3	157.0	156.7
161	160.7	160.3	160.0	159.6	159.3	159.0	158.7	158.3	158.0	157.7
162	161.7	161.3	161.0	160.6	160.3	160.0	159.7	159.3	159.0	158.7
163	162.7	162.4	162.0	161.7	161.4	161.1	160.7	160.4	160.0	159.7
164	163.7	163.4	163.0	162.7	162.4	162.1	161.7	161.4	161.0	160.7
165	164.7	164.4	164.0	163.7	163.4	163.1	162.7	162.4	162.0	161.7
166	165.7	165.4	165.0	164.7	164.4	164.1	163.7	163.4	163.0	162.7
167	166.7	166.4	166.0	165.7	165.4	165.1	164.8	164.4	164.1	163.8
168	167.7	167.4	167.0	166.7	166.4	166.1	165.8	165.4	165.1	164.8
169	168.7	168.4	168.0	167.7	167.4	167.1	166.8	166.4	166.1	165.8
170	169.7	169.4	169.0	168.7	168.4	168.1	167.8	167.4	167.1	166.8
171	170.7	170.4	170.0	169.7	169.4	169.1	168.8	168.4	168.1	167.8
172	171.7	171.4	171.0	170.7	170.4	170.1	169.8	169.5	169.2	168.9
173	172.7	172.4	172.1	171.8	171.5	171.2	170.9	170.5	170.2	169.9
174	173.7	173.4	173.1	172.8	172.5	172.2	171.9	171.5	171.2	170.9
175	174.7	174.4	174.1	173.8	173.5	173.2	172.9	172.6	172.3	172.0
176	175.7	175.4	175.1	174.8	174.5	174.2	173.9	173.6	173.3	173.0
177	176.7	176.4	176.1	175.8	175.5	175.2	174.9	174.7	174.4	174.1
178	177.7	177.4	177.1	176.8	176.5	176.2	175.9	175.7	175.4	175.1
179	178.7	178.4	178.1	177.8	177.5	177.2	176.9	176.7	176.4	176.1
180	179.7	179.4	179.2	178.9	178.6	178.3	178.0	177.7	177.4	177.1
181	180.7	180.4	180.2	179.9	179.6	179.3	179.0	178.8	178.5	178.2
182	181.7	181.4	181.2	180.9	180.6	180.3	180.0	179.8	179.5	179.2
183	182.7	182.4	182.2	181.9	181.6	181.3	181.0	180.8	180.5	180.2
184	183.7	183.4	183.2	182.9	182.6	182.3	182.0	181.8	181.5	181.2
185	184.7	184.4	184.2	183.9	183.6	183.3	183.1	182.8	182.6	182.3
186	185.7	185.5	185.2	185.0	184.7	184.4	184.1	183.9	183.6	183.3
187	186.7	186.5	186.2	186.0	185.7	185.4	185.1	184.9	184.6	184.3
188	187.8	187.5	187.3	187.0	186.8	186.5	186.2	186.0	185.7	185.4
189	188.8	188.5	188.3	188.0	187.8	187.5	187.3	187.0	186.8	186.5
190	189.8	189.5	189.3	189.0	188.8	188.6	188.3	188.1	187.8	187.6
191	190.8	190.5	190.3	190.0	189.8	189.6	189.3	189.1	188.8	188.6
192	191.8	191.6	191.3	191.1	190.9	190.7	190.4	190.2	189.9	189.7
193	192.8	192.6	192.3	192.1	191.9	191.7	191.4	191.2	190.9	190.7
194	193.8	193.6	193.3	193.1	192.9	192.7	192.4	192.2	191.9	191.7
195	194.8	194.6	194.3	194.1	193.9	193.7	193.5	193.2	193.0	192.8
196	195.8	195.6	195.3	195.1	194.9	194.7	194.5	194.2	194.0	193.8
197	196.8	196.6	196.4	186.2	196.0	195.8	195.5	195.3	195.0	194.8
198	197.8	197.6	197.4	197.2	197.0	196.8	196.6	196.3	196.1	195.9
199	198.8	198.6	198.4	198.2	198.0	197.8	197.6	197.3	197.1	196.9
200	199.8	199.6	199.4	199.2	199.0	198.8	198.6	198.3	198.1	197.9

TRUE PER CENT.

Ind. 2 to 65. Temp. 71° to 80°.

Indication.	TEMPERATURES.									
	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
2	0.5	0.4	0.2	0.1	....	....	....	....	....	....
3	1.5	1.4	1.2	1.1	0.9	0.7	0.5	0.3	0.1	....
4	2.5	2.4	2.2	2.1	1.9	1.7	1.5	1.4	1.2	1.0
5	3.5	3.4	3.2	3.1	2.9	2.7	2.5	2.4	2.2	2.0
6	4.5	4.4	4.2	4.1	3.9	3.7	3.5	3.3	3.1	2.9
7	5.5	5.3	5.2	5.0	4.8	4.6	4.4	4.3	4.1	3.9
8	6.5	6.3	6.2	6.0	5.8	5.6	5.4	5.2	5.0	4.8
9	7.5	7.3	7.2	7.0	6.8	6.6	6.4	6.2	6.0	5.8
10	8.4	8.2	8.1	7.9	7.7	7.5	7.3	7.1	6.9	6.7
11	9.4	9.2	9.1	8.9	8.7	8.5	8.3	8.1	7.9	7.7
12	10.3	10.1	10.0	9.8	9.6	9.4	9.2	9.0	8.8	8.6
13	11.3	11.1	10.9	10.7	10.5	10.3	10.1	9.8	9.6	9.4
14	12.2	12.0	11.8	11.6	11.4	11.2	11.0	10.7	10.5	10.3
15	13.2	13.0	12.7	12.5	12.3	12.1	11.9	11.6	11.4	11.2
16	14.1	13.9	13.7	13.5	13.3	13.1	12.8	12.6	12.3	12.1
17	15.1	14.9	14.7	14.5	14.3	14.1	13.8	13.6	13.3	13.1
18	16.1	15.9	15.6	15.4	15.2	15.0	14.8	14.5	14.3	14.1
19	17.0	16.8	16.6	16.4	16.2	16.0	15.7	15.5	15.2	15.0
20	18.0	17.8	17.5	17.3	17.1	16.9	16.7	16.4	16.2	16.0
21	18.9	18.7	18.4	18.2	18.0	17.8	17.5	17.3	17.0	16.8
22	19.8	19.6	19.3	19.1	18.9	18.6	18.4	18.1	17.9	17.6
23	20.7	20.4	20.2	19.9	19.7	19.5	19.2	19.0	18.7	18.5
24	21.6	21.4	21.1	20.9	20.6	20.3	20.1	19.8	19.6	19.3
25	22.5	22.3	22.0	21.8	21.5	21.2	21.0	20.7	20.5	20.2
26	23.5	23.3	23.0	22.8	22.5	22.2	21.9	21.7	21.4	21.1
27	24.4	24.2	23.9	23.7	23.4	23.1	22.8	22.6	22.3	22.0
28	25.4	25.1	24.9	24.6	24.3	24.0	23.7	23.5	23.2	22.9
29	26.3	26.0	25.8	25.5	25.2	24.9	24.6	24.4	24.1	23.8
30	27.2	26.9	26.7	26.4	26.1	25.8	25.5	25.3	25.0	24.7
31	28.1	27.8	27.6	27.3	27.0	26.7	26.4	26.1	25.8	25.5
32	29.0	28.7	28.5	28.2	27.9	27.6	27.3	27.0	26.7	26.4
33	29.9	29.6	29.4	29.1	28.8	28.5	28.2	27.8	27.5	27.2
34	30.9	30.6	30.3	30.0	29.7	29.4	29.1	28.7	28.4	28.1
35	31.8	31.5	31.2	30.9	30.6	30.3	30.0	29.6	29.3	29.0
36	32.7	32.4	32.1	31.8	31.5	31.2	30.8	30.5	30.1	29.8
37	33.7	33.4	33.0	32.7	32.4	32.1	31.7	31.4	31.0	30.7
38	34.6	34.3	33.9	33.6	33.3	32.9	32.6	32.2	31.9	31.5
39	35.5	35.2	34.8	34.5	34.2	33.8	33.5	33.1	32.8	32.4
40	36.4	36.1	35.7	35.4	35.1	34.7	34.4	34.0	33.7	33.3
41	37.3	37.0	36.6	36.3	36.0	35.6	35.3	34.9	34.6	34.2
42	38.2	37.8	37.5	37.1	36.8	36.5	36.1	35.8	35.4	35.1
43	39.1	38.7	38.4	38.0	37.7	37.3	37.0	36.6	36.3	35.9
44	39.9	39.6	39.2	38.9	38.5	38.1	37.8	37.4	37.1	36.7
45	40.8	40.5	40.1	39.8	39.4	39.0	38.7	38.3	38.0	37.6
46	41.7	41.3	40.9	40.5	40.1	39.8	39.4	39.1	38.7	38.4
47	42.6	42.2	41.9	41.5	41.1	40.7	40.3	40.0	39.6	39.2
48	43.5	43.1	42.8	42.4	42.0	41.6	41.2	40.8	40.4	40.0
49	44.5	44.1	43.6	43.2	42.8	42.4	42.0	41.7	41.3	40.9
50	45.4	45.0	44.5	44.1	43.7	43.3	42.9	42.5	42.1	41.7
51	46.4	45.9	45.5	45.0	44.6	44.2	43.8	43.3	42.9	42.5
52	47.4	46.9	46.5	46.0	45.6	45.2	44.7	44.3	43.8	43.4
53	48.4	47.9	47.5	47.0	46.6	46.1	45.7	45.2	44.8	44.3
54	49.3	48.9	48.4	48.0	47.5	47.1	46.6	46.2	45.7	45.3
55	50.3	49.8	49.4	48.9	48.5	48.0	47.6	47.1	46.7	46.2
56	51.3	50.8	50.4	49.9	49.5	49.0	48.6	48.1	47.7	47.2
57	52.2	51.8	51.3	50.9	50.5	50.0	49.6	49.1	48.7	48.2
58	53.2	52.7	52.3	51.8	51.4	51.0	50.5	50.1	49.6	49.2
59	54.1	53.7	53.2	52.8	52.4	52.0	51.5	51.1	50.6	50.2
60	55.1	54.6	54.2	53.7	53.3	52.9	52.4	52.0	51.5	51.1
61	56.1	55.6	55.2	54.7	54.3	53.9	53.4	53.0	52.5	52.1
62	57.1	56.6	56.2	55.7	55.3	54.8	54.4	53.9	53.5	53.0
63	58.1	57.6	57.2	56.7	56.3	55.8	55.4	54.9	54.5	54.0
64	59.0	58.6	58.1	57.7	57.2	56.8	56.3	55.9	55.4	55.0
65	60.0	59.6	59.1	58.7	58.2	57.8	57.3	56.9	56.4	56.0

TRUE PER CENT.

Ind. 66 to 130. Temp. 71° to 80°.

Indication.	TEMPERATURES.									
	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
66	61.0	60.6	60.1	59.7	59.2	58.7	58.3	57.8	57.4	56.9
67	62.0	61.6	61.1	60.7	60.2	59.7	59.3	58.8	58.4	57.9
68	63.0	62.6	62.1	61.7	61.2	60.7	60.3	59.8	59.4	58.9
69	64.0	63.6	63.1	62.7	62.2	61.7	61.3	60.8	60.4	59.9
70	65.0	64.6	64.1	63.7	63.2	62.7	62.3	61.8	61.4	60.9
71	66.0	65.6	65.1	64.7	64.2	63.7	63 3	62.8	62.4	61.9
72	67.0	66.6	66.1	65.7	65.2	64.7	64.3	63.8	63.4	62.9
73	68.0	67.6	67.1	66.7	66.2	65.7	65.3	64.8	64.4	63.9
74	69.0	68.6	68.1	67.7	67.2	66.7	66.3	65.8	65.4	64.9
75	70.0	69.6	69.1	68.7	68.2	67.7	67.3	66.8	66.4	65.9
76	71.0	70.6	70.1	69.7	69.2	68.7	68.3	67.8	67.4	66.9
77	72.0	71.6	71.1	70.7	70.2	69.7	69.3	68.8	68.4	67.9
78	73.0	72.6	72.1	71.7	71.2	70.7	70.3	69.8	69.4	68.9
79	74.0	73.6	73.1	72.7	72.2	71.7	71.3	70.8	70.4	69.9
80	75.0	74.6	74.1	73.7	73.2	72.7	72.3	71.8	71.4	70.9
81	76.0	75.6	75.1	74.7	74.2	73.7	73.3	72.8	72.4	71.9
82	77.0	76.6	76.1	75.7	75.2	74.7	74.3	73.8	73.4	72.9
83	78.1	77.6	77.2	76.7	76.3	75.8	75.3	74.9	74.4	73.9
84	79.1	78.6	78.2	77.7	77.3	76.8	76.4	75.9	75.5	75.0
85	80.1	79.6	79.2	78.7	78.3	77.8	77.4	76.9	76.5	76.0
86	81.1	80.7	80.2	79.8	79.3	78.8	78.4	77.9	77.5	77.0
87	82.2	81.7	81.3	80.8	80.4	79.9	79.5	79.0	78.6	78.1
88	83.2	82.7	82.3	81.8	81.4	81.0	80.5	80.1	79.6	79.2
89	84.2	83.7	83.3	82.8	82.4	82.0	81.5	81.1	80.6	80.2
90	85.2	84.8	84.3	83.9	83.4	83.0	82.5	82.1	81.6	81.2
91	86.3	85.8	85.4	84.9	84.5	84.0	83.6	83.1	82.7	82.2
92	87.3	86.8	86.4	85.9	85.5	85.0	84.6	84.1	83.7	83.2
93	88.3	87.8	87.4	86.9	86.5	86.1	85.6	85.2	84.7	84.3
94	89.3	88.8	88.4	87.9	87.5	87.1	86.6	86.2	85.7	85.3
95	90.3	89.8	89.4	88.9	88.5	88.1	87.6	87.2	86.7	86.3
96	91.3	90.9	90.4	90.0	89.6	89.1	88.7	88.2	87.8	87.3
97	92.3	91.9	91.4	91.0	90.6	90.1	89.7	89.2	88.8	88.3
98	93.4	92.9	92.5	92.0	91.6	91.2	90.7	90.3	89.8	89.4
99	94.4	93.9	93.5	93.0	92.6	92.2	91.7	91.3	90.8	90.4
100	95.4	95.0	94.5	94.1	93.7	93.3	92.8	92.4	91.9	91.5
101	96.4	96.0	95.5	95.1	94.7	94.3	93.8	93.4	92.9	92.5
102	97.4	97.0	96.5	96.1	95.7	95.3	94.8	94.4	93.9	93.5
103	98.4	98.0	97.5	97.1	96.7	96.3	95.9	95.4	95.0	94.6
104	99.5	99.0	98.6	98.1	97.7	97.3	96.9	96.4	96.0	95.6
105	100.5	100.1	99.6	99.2	98.8	98.4	98.0	97.5	97.1	96.7
106	101.5	101.1	100.6	100.2	99.8	99.4	99.0	98.5	98.1	97.7
107	102.5	102.1	101.7	101.3	100.9	100.5	100.0	99.6	99.1	98.7
108	103.5	103.1	102.7	102.3	101.9	101.5	101.1	100.6	100.2	99.8
109	104.5	104.1	103.7	103.3	102.9	102.5	102.1	101.6	101.2	100.8
110	105.5	105.1	104.7	104.3	103.9	103.5	103.1	102.7	102.3	101.9
111	106.6	106.2	105.7	105.3	104.9	104.5	104.1	103.7	103.3	102.9
112	107.6	107.2	106.7	106.3	105.9	105.5	105.1	104.7	104.3	103.9
113	108.6	108.2	107.8	107.4	107.0	106.6	106.2	105.7	105.3	104.9
114	109.6	109.2	108.8	108.4	108.0	107.6	107.2	106.7	106.3	105.9
115	110.6	110.2	109.8	109.4	109 0	108.6	108.2	107.7	107.3	106.9
116	111.6	111.2	110.8	110.4	110.0	109.6	109.2	108.7	108.3	107.9
117	112.6	112.2	111.8	111.4	111.0	110.6	110.2	109.7	109.3	108.9
118	113.7	113.3	112.8	112.4	112.0	111.6	111.2	110.7	110.3	109.9
119	114.7	114.3	113.9	113.5	113.1	112.7	112.3	111.8	111.4	111.0
120	115.7	115 3	114.9	114.5	114.1	113.7	113.3	112.9	112.5	112.1
121	116.7	116.3	115.9	115.5	115.1	114.7	114.3	113.9	113.5	113.1
122	117.7	117.3	117.0	116.6	116.2	115.8	115.4	114.9	114.5	114.1
123	118.7	118.3	118.0	117.6	117.2	116.8	116.4	116.0	115.6	115.2
124	119.7	119.3	119.0	118.6	118.2	117.8	117.4	117.0	116.6	116.2
125	120.7	120.3	120.0	119.6	119.2	118.8	118.4	118.0	117.6	117.2
126	121.7	121.3	121.0	120.6	120.2	119.8	119.4	119.0	118.6	118.2
127	122.7	122.3	122.0	121.6	121.2	120.8	120.4	120.0	119.6	119.2
128	123.8	123.4	123.0	122.6	122.2	121.8	121.4	121.0	120.6	120.2
129	124.8	124 4	124.0	123.6	123.2	122.8	122.4	122.0	121.6	121.2
130	125.8	125.4	125.0	124.6	124.2	123.8	123.4	123.0	122.6	122.2

TRUE PER CENT.

Ind. 131 to 200. Temp. 71° to 80°.

Indication.	TEMPERATURES.									
	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
131	126.8	126.4	126.0	125.6	125.2	124.8	124.4	124.0	123.6	123.2
132	127.8	127.4	127.1	126.7	126.3	125.9	125.5	125.1	124.7	124.3
133	128.9	128.5	128.1	127.7	127.3	126.9	126.5	126.1	125.7	125.3
134	129.9	129.5	129.1	128.7	128.3	127.9	127.5	127.2	126.8	126.4
135	130.9	130.5	130.2	129.8	129.4	129.0	128.6	128.2	127.8	127.4
136	131.9	131.5	131.2	130.8	130.4	130.0	129.6	129.3	128.9	128.5
137	132.9	132.5	132.2	131.8	131.4	131.0	130.6	130.3	129.9	129.5
138	133.9	133.5	133.2	132.8	132.4	132.0	131.6	131.3	130.9	130.5
139	134.9	134.5	134.2	133.8	133.4	133.0	132.6	132.3	131.9	131.5
140	136.0	135.6	135.3	134.9	134.5	134.1	133.7	133.4	133.0	132.6
141	137.0	136.6	136.3	135.9	135.5	135.1	134.7	134.4	134.0	133.6
142	138.0	137.6	137.3	136.9	136.5	136.1	135.8	135.4	135.1	134.7
143	139.0	138.6	138.3	137.9	137.5	137.1	136.8	136.4	136.1	135.7
144	140.0	139.7	139.3	139.0	138.6	138.2	137.8	137.5	137.1	136.7
145	141.0	140.7	140.3	140.0	139.6	139.2	138.8	138.5	138.1	137.7
146	142.0	141.7	141.3	141.0	140.6	140.2	139.8	139.5	139.1	138.7
147	143.0	142.7	142.3	142.0	141.6	141.2	140.8	140.5	140.1	139.7
148	144.0	143.7	143.3	143.0	142.6	142.2	141.9	141.5	141.2	140.8
149	145.1	144.8	144.4	144.1	143.7	143.3	142.9	142.6	142.2	141.8
150	146.1	145.8	145.4	145.1	144.7	144.3	143.9	143.6	143.2	142.8
151	147.1	146.8	146.4	146.1	145.7	145.3	145.0	144.6	144.3	143.9
152	148.1	147.8	147.4	147.1	146.7	146.3	146.0	145.6	145.3	144.9
153	149.2	148.8	148.5	148.1	147.8	147.4	147.0	146.7	146.3	145.9
154	150.2	149.8	149.5	149.1	148.8	148.4	148.0	147.7	147.3	146.9
155	151.2	150.8	150.5	150.1	149.8	149.4	149.1	148.7	148.4	148.0
156	152.2	151.9	151.5	151.2	150.8	150.4	150.1	149.7	149.4	149.0
157	153.3	152.9	152.6	152.2	151.9	151.5	151.1	150.8	150.4	150.0
158	154.3	153.9	153.6	153.2	152.9	152.5	152.2	151.8	151.5	151.1
159	155.3	154.9	154.6	154.2	153.9	153.5	153.2	152.8	152.5	152.1
160	156.3	156.0	155.6	155.3	154.9	154.6	154.2	153.9	153.5	153.2
161	157.4	157.0	156.7	156.3	156.0	155.6	155.3	154.9	154.6	154.2
162	158.4	158.0	157.7	157.3	157.0	156.7	156.3	156.0	155.6	155.3
163	159.4	159.0	158.7	158.3	158.0	157.7	157.3	157.0	156.6	156.3
164	160.4	160.0	159.7	159.3	159.0	158.7	158.3	158.0	157.6	157.3
165	161.4	161.1	160.7	160.4	160.1	159.8	159.4	159.1	158.7	158.4
166	162.4	162.1	161.7	161.4	161.1	160.8	160.4	160.1	159.7	159.4
167	163.5	163.1	162.8	162.4	162.1	161.8	161.4	161.1	160.7	160.4
168	164.5	164.1	163.8	163.4	163.1	162.8	162.5	162.1	161.8	161.5
169	165.5	165.2	164.8	164.5	164.2	163.9	163.5	163.2	162.8	162.5
170	166.5	166.2	165.8	165.5	165.2	164.9	164.5	164.2	163.8	163.5
171	167.5	167.2	166.8	166.5	166.2	165.9	165.6	165.2	164.9	164.6
172	168.6	168.2	167.9	167.5	167.2	166.9	166.6	166.2	165.9	165.6
173	169.6	169.3	168.9	168.6	168.3	168.0	167.7	167.3	167.0	166.7
174	170.6	170.3	169.9	169.6	169.3	169.0	168.7	168.3	168.0	167.7
175	171.7	171.4	171.0	170.7	170.4	170.1	169.8	169.4	169.1	168.8
176	172.7	172.4	172.0	171.7	171.4	171.1	170.8	170.4	170.1	169.8
177	173.8	173.5	173.1	172.8	172.5	172.2	171.9	171.5	171.2	170.9
178	174.8	174.5	174.1	173.8	173.5	173.2	172.9	172.6	172.3	172.0
179	175.8	175.5	175.2	174.9	174.6	174.3	174.0	173.6	173.3	173.0
180	176.8	176.5	176.2	175.9	175.6	175.3	175.0	174.7	174.4	174.1
181	177.9	177.6	177.3	177.0	176.7	176.4	176.1	175.8	175.5	175.2
182	178.9	178.6	178.3	178.0	177.7	177.4	177.1	176.8	176.5	176.2
183	179.9	179.6	179.3	179.1	178.8	178.5	178.2	177.9	177.6	177.3
184	180.9	180.6	180.4	180.1	179.8	179.5	179.2	179.0	178.7	178.4
185	182.0	181.7	181.4	181.1	180.8	180.5	180.2	180.0	179.7	179.4
186	183.0	182.7	182.5	182.2	181.9	181.6	181.3	181.1	180.8	180.5
187	184.0	183.8	183.5	183.3	183.0	182.7	182.4	182.1	181.8	181.5
188	185.1	184.9	184.6	184.4	184.1	183.8	183.5	183.2	182.9	182.6
189	186.2	186.0	185.7	185.5	185.2	184.9	184.6	184.4	184.1	183.8
190	187.3	187.1	186.8	186.6	186.3	186.0	185.8	185.5	185.3	185.0
191	188.4	188.1	187.9	187.6	187.4	187.1	186.9	186.6	186.4	186.1
192	189.4	189.2	188.9	188.7	188.4	188.2	187.9	187.7	187.4	187.2
193	190.5	190.2	190.0	189.7	189.5	189.3	189.0	188.8	188.5	188.3
194	191.5	191.3	191.0	190.8	190.6	190.4	190.1	189.9	189.6	189.4
195	192.6	192.3	192.1	191.8	191.6	191.4	191.2	190.9	190.7	190.5
196	193.6	193.4	193.1	192.9	192.7	192.5	192.2	192.0	191.7	191.5
197	194.6	194.4	194.1	193.9	193.7	193.5	193.3	193.0	192.8	192.6
198	195.7	195.5	195.2	195.0	194.8	194.6	194.4	194.1	193.9	193.7
199	196.7	196.5	196.3	196.1	195.9	195.7	195.4	195.2	194.9	194.7
200	197.7	197.5	197.3	197.1	196.9	196.7	196.5	196.2	196.0	195.8

TRUE PER CENT.

Ind. 4 to 65. Temp. 81° to 90°.

Indication.	TEMPERATURES.									
	81°	82°	83°	84°	85°	86°	87°	88°	89°	90°
4	0.8	0.5	0.3	0.0	....	....	....	....	....	....
5	1.8	1.5	1.3	1.0	0.8	0.6	0.3	0.1	....	....
6	2.7	2.5	2.2	2.9	1.8	1.6	1.3	1.1	0.8	0.6
7	3.7	3.4	3.2	2.9	2.7	2.5	2.2	2.0	1.7	1.5
8	4.6	4.4	4.1	3.9	3.7	3.5	3.2	3.0	2.7	2.5
9	5.6	5.4	5.1	4.9	4.7	4.5	4.2	4.0	3.7	3.5
10	6.5	6.3	6.0	5.8	5.6	5.4	5.1	4.9	4.6	4.4
11	7.5	7.2	7.0	6.7	6.5	6.3	6.0	5.8	5.5	5.3
12	8.4	8.1	7.9	7.6	7.4	7.2	6.9	6.7	6.4	6.2
13	9.2	9.0	8.7	8.5	8.3	8.0	7.8	7.5	7.3	7.0
14	10.1	9.8	9.6	9.3	9.1	8.9	8.6	8.4	8.1	7.9
15	11.0	10.7	10.5	10.2	10.0	9.7	9.5	9.2	9.0	8.7
16	11.9	11.6	11.4	11.1	10.9	10.6	10.4	10.1	9.9	9.6
17	12.8	12.6	12.3	12.1	11.8	11.5	11.3	11.0	10.8	10.5
18	13.8	13.5	13.3	13.0	12.7	12.4	12.1	11.9	11.6	11.3
19	14.7	14.5	14.2	14.0	13.7	13.4	13.1	12.8	12.5	12.2
20	15.7	15.4	15.2	14.9	14.6	14.3	14.0	13.7	13.4	13.1
21	16.5	16.2	16.0	15.7	15.4	15.1	14.8	14.6	14.3	14.0
22	17.3	17.1	16.8	16.6	16.3	16.0	15.7	15.4	15.1	14.8
23	18 2	17.9	17.7	17.4	17.1	16.8	16.5	16.3	16.0	15.7
24	19.0	18.8	18.5	18.3	18.0	17.7	17.4	17.1	16.8	16.5
25	19.9	19.6	19.4	19.1	18.8	18.5	18.2	17.9	17.6	17.3
26	20.8	20.5	20.3	20.0	19.7	19.4	19.1	18.8	18.5	18.2
27	21.7	21.4	21.1	20.8	20.5	20.2	19.9	19.6	19.3	19.0
28	22.6	22.3	22.0	21.7	21.4	21.1	20.8	20.4	20.1	19.8
29	23.5	23.2	22.9	22.6	22.3	22.0	21.7	21.3	21.0	20.7
30	24.4	24.1	23.7	23.4	23.1	22.8	22.5	22.1	21.8	21.5
31	25.2	24.9	24.6	24.3	24.0	23.7	23.3	23.0	22.6	22.3
32	26.1	25.8	25.4	25.1	24.8	24.5	24.1	23.8	23.4	23.1
33	26.9	26.6	26.2	25.9	25.6	25.3	25.0	24.6	24.3	24.0
34	27.8	27.5	27.1	26.8	26.5	26.2	25.8	25.5	25.1	24.8
35	28.7	28.3	28.0	27.6	27.3	27.0	26.6	26.3	25.9	25.6
36	29.5	29.1	28.8	28.4	28.1	27.8	27.4	27.1	26.7	26.4
37	30.4	30.0	29.7	29.3	29.0	28.6	28.3	27.9	27.6	27.2
38	31.2	30.8	30.5	30.1	29.8	29.5	29.1	28.8	28.4	28.1
39	32.1	31.7	31.4	31.0	30.7	30.3	30.0	29.6	29.3	28.9
40	32.9	32.6	32.2	31.9	31.5	31.1	30.8	30.4	30.1	29.7
41	33.8	33.5	33.1	32.8	32.4	32.0	31.6	31.2	30.8	30.4
42	34.7	34.3	34.0	33.6	33.2	32 8	32.4	32.1	31.7	31.3
43	35.5	35.2	34.8	34.5	34.1	33.7	33.3	32.9	32.5	32.1
44	36.3	36.0	35.6	35.3	34.9	34.5	34.1	33.8	33.4	33.0
45	37.2	36.0	36.5	36.2	35.8	35.4	35.0	34.7	34.3	33.9
46	38.0	37.7	37.3	37.0	36.6	36.2	35.8	35.5	35.1	34.7
47	38.8	38.5	38.1	37.8	37.4	37.0	36.6	36.3	35.9	35.5
48	39.6	39.3	38.9	38.6	38.2	37.8	37.4	37.1	36.7	36.3
49	40.5	40.1	39.8	39.4	39.0	38.6	38.2	37.9	37.5	37.1
50	41.3	40.9	40.6	40.2	39.8	39.4	39.0	38.7	38.3	37.9
51	42.1	41.7	41.4	41.0	40.6	40.2	39.8	39.4	39.0	38.6
52	43.0	42.6	42.2	41.8	41.4	41.0	40.6	40.2	39.8	39.4
53	43.9	43.5	43.0	42.6	42.2	41.8	41.4	41.0	40.6	40.2
54	44.8	44.4	43.9	43.5	43.0	42.6	42.2	41.8	41.4	41.0
55	45.7	45.2	44.8	44.3	43.8	43.4	43.0	42.6	42.2	41.8
56	46 7	46.2	45.8	45.3	44.8	44.4	43.9	43.5	43.0	42.6
57	47.7	47.2	46.8	46.3	45.8	45.3	44.8	44.4	43.9	43.4
58	48.7	48.2	47.8	47.3	46.8	46.3	45.8	45.3	44.8	44.3
59	49.7	49.2	48.8	48.3	47.8	47.3	46.8	46.3	45.8	45.3
60	50.6	50.2	49.7	49.3	48.8	48.3	47.8	47.3	46.8	46.3
61	51.6	51.2	50.7	50.3	49.8	49.3	48.8	48.3	47.8	47.3
62	52.6	52.1	51.7	51.2	50.8	50.3	49.8	49.3	48.8	48.3
63	53 5	53.1	52.6	52.2	51.7	51.2	50.7	50.3	49.8	49.3
64	54.5	54.1	53.6	35.2	52.7	52.2	51.7	51.3	50.8	50.3
65	55.5	55.1	54.6	54.2	53.7	53.2	52.7	52.3	51.8	51.3

TRUE PER CENT.

Ind. 66 to 130. Temp. 81° to 90°.

Indication.	TEMPERATURES.									
	81°	82°	83°	84°	85°	86°	87°	88°	89°	90°
66	56.5	56.0	55.6	55.1	54.7	54.2	53.7	53.3	52.8	52.3
67	57.4	57.0	56.5	56.1	55.6	55.1	54.7	54.2	53.8	53.3
68	58.4	58.0	57.5	57.1	56.6	56.1	55.7	55.2	54.8	54.3
69	59.4	59.0	58.5	58.1	57.6	57.1	56.7	56.2	55.8	55.3
70	60.4	60.0	59.5	59.1	58.6	58.1	57.7	57.2	56.8	56.3
71	61.4	61.0	60.5	60.1	59.6	59.1	58.7	58.2	57.8	57.3
72	62.5	62.0	61.6	61.1	60.7	60.2	59.7	59.3	58.8	58.3
73	63.5	63.0	62.6	62.1	61.7	61.2	60.7	60.3	59.8	59.3
74	64.5	64.0	63.6	63.1	62.7	62.2	61.8	61.3	60.9	60.4
75	65.5	65.0	64.6	64.1	63.7	63.2	62.8	62.3	61.9	61.4
76	66.5	66.0	65.6	65.1	64.7	64.2	63.8	63.3	62.9	62.4
77	67.5	67.0	66.6	66.1	65.7	65.2	64.8	64.3	63.9	63.4
78	68.5	68.0	67.6	67.1	66.7	66.2	65.8	65.3	64.9	64.4
79	69.5	69.0	68.6	68.1	67.7	67.3	66.8	66.4	65.9	65.5
80	70.5	70.0	69.6	69.1	68.7	68.3	67.8	67.4	66.9	66.5
81	71.5	71.0	70.6	70.1	69.7	69.3	68.8	68.4	67.9	67.5
82	72.5	72.0	71.6	71.1	70.7	70.3	69.8	69.4	68.9	68.5
83	73.5	73.0	72.6	72.1	71.7	71.3	70.8	70.4	69.9	69.5
84	74.5	74.1	73.6	73.2	72.7	72.3	71.8	71.4	70.9	70.5
85	75.5	75.1	74.6	74.2	73.7	73.3	72.8	72.4	71.9	71.5
86	76.5	76.1	75.6	75.2	74.7	74.3	73.8	73.4	72.9	72.5
87	77.6	77.1	76.7	76.2	75.7	75.3	74.8	74.4	73.9	73.5
88	78.7	73.2	77.8	77.3	76.8	76.3	75.9	75.4	75.0	74.5
89	79.7	79.2	78.8	78.3	77.8	77.3	76.9	76.4	76.0	75.5
90	80.7	80.3	79.8	79.4	78.9	78.4	77.9	77.5	77.0	76.5
91	81.8	81.3	80.9	80.4	80.0	79.5	79.0	78.6	78.1	77.6
92	82.8	82.4	81.9	81.5	81.1	80.6	80.1	79.7	79.2	78.7
93	83.9	83.4	83.0	82.5	82.1	81.6	81.2	80.7	80.3	79.8
94	84.9	84.4	84.0	83.5	83.1	82.7	82.2	81.8	81.3	80.9
95	85.9	85.4	85.0	84.5	84.1	83.7	83.2	82.8	82.3	81.9
96	86.9	86.4	86.0	85.5	85.1	84.7	84.3	83.8	83.4	83.0
97	87.9	87.4	87.0	86.5	86.1	85.7	85.3	84.8	84.4	84.0
98	88.9	88.5	88.0	87.6	87.1	86.7	86.3	85.8	85.4	85.0
99	90.0	89.5	89.1	88.6	88.2	87.8	87.3	86.9	86.4	86.0
100	91.0	90.6	90.1	89.7	89.2	88.8	88.3	87.9	87.4	87.0
101	92.1	91.6	91.2	90.7	90.3	89.8	89.4	88.9	88.5	88.0
102	93.1	92.7	92.2	91.8	91.4	90.9	90.5	90.0	89.6	89.1
103	94.2	93.7	93.3	92.8	92.4	92.0	91.5	91.1	90.6	90.2
104	95.2	94.8	94.3	93.9	93.5	93.1	92.6	92.2	91.7	91.3
105	96.3	95.8	95.4	94.9	94.5	94.1	93.6	93.2	92.7	92.3
106	97.3	96.8	96.4	95.9	95.5	95.1	94.7	94.2	93.8	93.4
107	98.3	97.9	97.4	97.0	96.6	96.2	95.7	95.3	94.8	94.4
108	99.4	98.9	98.5	98.0	97.6	97.2	96.8	96.3	95.9	95.5
109	100.4	100.0	99.5	99.1	98.7	98.3	97.8	97.4	96.9	96.5
110	101.5	101.0	100.6	100.1	99.7	99.3	98.9	98.4	98.9	97.6
111	102.5	102.1	101.6	101.2	100.8	100.4	99.9	99.5	99.0	98.6
112	103.5	103.1	102.6	102.2	101.8	101.4	101.0	100.5	100.1	99.7
113	104.5	104.1	103.6	103.2	102.8	102.4	102.0	101.5	101.1	100.7
114	105.5	105.1	104.7	104.3	103.9	103.5	103.1	102.6	102.2	101.8
115	106.5	106.1	105.7	105.3	104.9	104.5	104.1	103.6	103.2	102.8
116	107.5	107.1	106.7	106.3	105.9	105.5	105.1	104.6	104.2	103.8
117	108.5	108.1	107.7	107.3	106.9	106.5	106.1	105.6	105.2	104.8
118	109.5	109.1	108.7	108.3	107.9	107.5	107.1	106.7	106.3	105.9
119	110.6	110.2	109.7	109.3	108.9	108.5	108.1	107.7	107.3	106.9
120	111.7	111.2	110.8	110.3	109.9	109.5	109.1	108.7	108.3	107.9
121	112.7	112.3	111.8	111.4	111.0	110.6	110.2	109.7	109.3	108.9
122	113.7	113.3	112.9	112.5	112.1	111.7	111.2	110.8	110.3	109.9
123	114.8	114.4	113.9	113.5	113.1	112.7	112.3	111.8	111.4	111.0
124	115.8	115.4	115.0	114.6	114.2	113.8	113.4	112.9	112.5	112.1
125	116.8	116.4	116.0	115.6	115.2	114.8	114.4	113.9	113.5	113.1
126	117.8	117.4	117.0	116.6	116.2	115.8	115.4	115.0	114.6	114.2
127	118.8	118.4	118.1	117.7	117.3	116.9	116.5	116.0	115.6	115.2
128	119.8	119.4	119.1	118.7	118.3	117.9	117.5	117.1	116.7	116.3
129	120.8	120.4	120.1	119.7	119.3	118.9	118.5	118.1	117.7	117.3
130	121.8	121.4	121.1	120.7	120.3	119.9	119.5	119.1	118.7	118.3

TRUE PER CENT.

Ind. 131 to 200. Temp. 81° to 90°.

Indication.	TEMPERATURES.									
	81°	82°	83°	84°	85°	86°	87°	88°	89°	90°
131	122.8	122.4	122.1	121.7	121.3	120.9	120.5	120.1	119.7	119.3
132	123.9	123.5	123.1	122.7	122.3	121.9	121.5	121.1	120.7	120.3
133	124.9	124.5	124.1	123.7	123.3	122.9	122.5	122.2	121.8	121.4
134	126.0	125.6	125.2	124.8	124.4	124.0	123.6	123.2	122.8	122.4
135	127.0	126.6	126.2	125.8	125.4	125.0	124.6	124.2	123.8	123.4
136	128.1	127.7	127.3	126.9	126.5	126.1	125.7	125.2	124.8	124.4
137	129.1	128.7	128.3	127.9	127.5	127.1	126.7	126.3	125.9	125.5
138	130.1	129.7	129.4	129.0	128.6	128.2	127.8	127.4	127.0	126.6
139	131.1	130.7	130.4	130.0	129.6	129.2	128.8	128.5	128.1	127.7
140	132.2	131.8	131.5	131.1	130.7	130.3	129.9	129.6	129.2	128.8
141	133.2	132.8	132.5	132.1	131.7	131.3	130.9	130.6	130.2	129.8
142	134.3	133.9	133.5	133.1	132.7	132.3	132.0	131.6	131.3	130.9
143	135.3	134.9	134.6	134.2	133.8	133.4	133.0	132.7	132.3	131.9
144	136.3	135.9	135.6	135.2	134.8	134.4	134.0	133.7	133.3	132.9
145	137.3	136.9	136.6	136.2	135.8	135.4	135.0	134.7	134.3	133.9
146	138.3	138.0	137.6	137.3	136.9	136.5	136.1	135.7	135.3	134.9
147	139.3	139.0	138.6	138.3	137.9	137.5	137.1	136.7	136.3	135.9
148	140.4	140.0	139.7	139.3	138.9	138.5	138.1	137.8	137.4	137.0
149	141.4	141.1	140.7	140.4	140.0	139.6	139.2	138.8	138.4	138.0
150	142.4	142.1	141.7	141.4	141.0	140.6	140.2	139.9	139.5	139.1
151	143.5	143.1	142.8	142.4	142.0	141.6	141.2	140.9	140.5	140.1
152	144.5	144.2	143.8	143.5	143.1	142.7	142.3	142.0	141.6	141.2
153	145.5	145.2	144.8	144.5	144.1	143.7	143.3	143.0	142.6	142.2
154	146.5	146.2	145.8	145.5	145.1	144.7	144.4	144.0	143.7	143.3
155	147.6	147.3	146.9	146.6	146.2	145.8	145.4	145.1	144.7	144.3
156	148.6	148.3	147.9	147.6	147.2	146.8	146.5	146.1	145.8	145.4
157	149.7	149.3	149.0	148.6	148.3	147.9	147.5	147.2	146.8	146.4
158	150.7	150.4	150.0	149.7	149.3	148.9	148.6	148.2	147.9	147.5
159	151.8	151.4	151.1	150.7	150.4	150.0	149.6	149.3	148.9	148.5
160	152.8	152.5	152.1	151.8	151.4	151.0	150.7	150.3	150.0	149.6
161	153.9	153.5	153.2	152.8	152.5	152.1	151.7	151.4	151.0	150.6
162	154.9	154.6	154.2	153.9	153.5	153.1	152.8	152.4	152.1	151.7
163	156.0	155.6	155.3	154.9	154.6	154.2	153.9	153.5	153.2	152.8
164	157.0	156.6	156.3	155.9	155.6	155.2	154.9	154.5	154.2	153.8
165	158.0	157.7	157.3	157.0	156.6	156.3	155.9	155.6	155.2	154.9
166	159.1	158.7	158.4	158.0	157.7	157.3	157.0	156.6	156.3	155.9
167	160.1	159.7	159.4	159.0	158.7	158.4	158.0	157.7	157.3	157.0
168	161.1	160.8	160.4	160.1	159.7	159.4	159.0	158.7	158.3	158.0
169	162.2	161.8	161.5	161.1	160.8	160.5	160.1	159.8	159.4	159.1
170	163.2	162.8	162.5	162.1	161.8	161.5	161.1	160.8	160.4	160.1
171	164.3	163.9	163.6	163.2	162.9	162.6	162.2	161.9	161.5	161.2
172	165.3	165.0	164.6	164.3	164.0	163.7	163.3	163.0	162.6	162.3
173	166.4	166.0	165.7	165.3	165.0	164.7	164.3	164.0	163.6	163.3
174	167.4	167.1	166.7	166.4	166.1	165.8	165.4	165.1	164.7	164.4
175	168.5	168.2	167.8	167.5	167.2	166.9	166.5	166.2	165.8	165.5
176	169.5	169.2	168.9	168.6	168.3	168.0	167.6	167.3	166.9	166.6
177	170.6	170.3	169.9	169.6	169.3	169.0	168.7	168.3	168.0	167.7
178	171.7	171.4	171.0	170.7	170.4	170.1	169.8	169.4	169.1	168.8
179	172.7	172.4	172.1	171.8	171.5	171.2	170.9	170.5	170.2	169.9
180	173.8	173.5	173.2	172.9	172.6	172.3	172.0	171.6	171.3	171.0
181	174.9	174.6	174.3	174.0	173.7	173.4	173.1	172.7	172.4	172.1
182	175.9	175.6	175.3	175.0	174.7	174.4	174.1	173.8	173.5	173.2
183	177.0	176.7	176.4	176.1	175.8	175.5	175.2	174.9	174.6	174.3
184	178.1	177.8	177.5	177.2	176.9	176.6	176.3	176.0	175.7	175.4
185	179.1	178.8	178.6	178.3	178.0	177.7	177.4	177.0	176.7	176.4
186	180.2	179.9	179.6	179.3	179.0	178.7	178.4	178.1	177.8	177.5
187	181.2	180.9	180.7	180.4	180.1	179.8	179.5	179.2	178.9	178.6
188	182.3	182.0	181.8	181.5	181.2	180.9	180.6	180.4	180.1	179.8
189	183.5	183.2	183.0	182.7	182.4	182.1	181.8	181.5	181.2	180.9
190	184.7	184.4	184.1	183.8	183.5	183.2	182.9	182.7	182.4	182.1
191	185.8	185.5	185.2	184.9	184.6	184.3	184.0	183.8	183.5	183.2
192	186.9	186.6	186.4	186.1	185.8	185.5	185.2	185.0	184.7	184.4
193	188.0	187.8	187.5	187.3	187.0	186.7	186.4	186.2	185.9	185.6
194	189.1	188.9	188.6	188.4	188.1	187.8	187.6	187.3	187.1	186.8
195	190.2	190.0	189.7	189.5	189.2	188.9	188.7	188.4	188.2	187.9
196	191.3	191.0	190.8	190.5	190.3	190.0	189.8	189.5	189.3	189.0
197	192.4	192.1	191.9	191.6	191.4	191.2	190.9	190.7	190.4	190.2
198	193.5	193.2	193.0	192.7	192.5	192.3	192.0	191.8	191.5	191.3
199	194.5	194.3	194.0	193.8	193.6	193.4	193.1	192.9	192.6	192.4
200	195.6	195.4	195.1	194.9	194.7	194.5	194.2	194.0	193.7	193.5

TRUE PER CENT.

Ind. 6 to 70. Temp. 91° to 100°.

Indication.	TEMPERATURES.									
	91°	92°	93°	94°	95°	96°	97°	98°	99°	100°
6	0.3	0.0	....	....	....	....	....	....	....	....
7	1.2	1.0	0.7	0.5	0.2	....	....	....	....	....
8	2.2	2.0	1.7	1.5	1.2	0.9	0.6	0.3	0.0	....
9	3.2	2.9	2.7	2.4	2.1	1.8	1.5	1.3	1.0	0.7
10	4.1	3.8	3.6	3.3	3.0	2.7	2.4	2.2	1.9	1.6
11	5.0	4.7	4.5	4.2	3.9	3.6	3.3	3.1	2.8	2.5
12	5.9	5.6	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3
13	6.7	6.4	6.2	5.9	5.6	5.3	5.0	4.7	4.4	4.1
14	7.6	7.3	7.1	6.8	6.5	6.2	5.9	5.6	5.3	5.0
15	8.4	8.1	7.9	7.6	7.3	7.0	6.7	6.4	6.1	5.8
16	9.3	9.0	8.7	8.4	8.1	7.8	7.5	7.2	6.9	6.6
17	10.2	9.9	9.6	9.3	9.0	8.7	8.4	8.1	7.8	7.5
18	11.0	10.7	10.5	10.2	9.9	9.6	9.3	8.9	8.6	8.3
19	11.9	11.6	11.3	11.0	10.7	10.4	10.1	9.7	9.4	9.1
20	12.8	12.5	12.2	11.9	11.6	11.3	11.0	10.6	10.3	10.0
21	13.7	13.4	13.1	12.8	12.5	12.2	11.8	11.5	11.1	10.8
22	14.5	14.2	13.9	13.6	13.3	13.0	12.6	12.3	11.9	11.6
23	15.4	15.1	14.7	14.4	14.1	13.8	13.4	13.1	12.7	12.4
24	16.2	15.9	15.5	15.2	14.9	14.6	14.2	13.9	13.5	13.2
25	17.0	16.7	16.3	16.0	15.7	15.4	15.0	14.7	14.3	14.0
26	17.9	17.5	17.2	16.8	16.5	16.2	15.8	15.5	15.1	14.8
27	18.7	18.4	18.0	17.7	17.4	17.0	16.7	16.3	16.0	15.6
28	19.5	19.2	18.8	18.5	18.2	17.8	17.5	17.1	16.8	16.4
29	20.4	20.0	19.7	19.3	19.0	18.6	18.3	17.9	17.6	17.2
30	21.2	20.8	20.5	20.1	19.8	19.4	19.1	18.7	18.4	18.0
31	22.0	21.6	21.3	20.9	20.6	20.2	19.9	19.5	19.2	18.8
32	22.8	22.4	22.1	21.7	21.4	21.0	20.6	20.3	19.9	19.5
33	23.6	23.3	22.9	22.6	22.2	21.8	21.4	21.1	20.7	20.3
34	24.4	24.1	23.7	23.4	23.0	22.6	22.2	21.9	21.5	21.1
35	25.2	24.9	24.5	24.2	23.8	23.4	23.0	22.7	22.3	21.9
36	26.0	25.7	25.3	25.0	24.6	24.2	23.8	23.5	23.1	22.7
37	26.8	26.5	26.1	25.8	25.4	25.0	24.6	24.3	23.9	23.5
38	27.7	27.3	27.0	26.6	26.2	25.8	25.4	25.1	24.7	24.3
39	28.5	28.1	27.8	27.4	27.0	26.6	26.2	25.8	25.4	25.0
40	29.3	28.9	28.6	28.2	27.8	27.4	27.0	26.6	26.2	25.8
41	30.0	29.7	29.3	29.0	28.6	28.2	27.8	27.4	27.0	26.6
42	30.9	30.5	30.2	29.8	29.4	29.0	28.6	28.2	27.8	27.4
43	31.7	31.3	31.0	30.6	30.2	29.8	29.4	29.0	28.6	28.2
44	32.6	32.2	31.8	31.4	31.0	30.6	30.2	29.7	29.3	28.9
45	33.5	33.1	32.6	32.2	31.8	31.4	31.0	30.5	30.1	29.7
46	34.3	33.9	33.5	33.1	32.7	32.3	31.9	31.4	31.0	30.6
47	35.1	34.7	34.3	33.9	33.5	33.1	32.7	32.2	31.8	31.4
48	35.9	35.5	35.1	34.7	34.3	33.9	33.5	33.0	32.6	32.2
49	36.7	36.3	35.9	35.5	35.1	34.7	34.3	33.8	33.4	33.0
50	37.5	37.1	36.7	36.3	35.9	35.5	35.1	34.6	34.2	33.8
51	38.2	37.8	37.5	37.1	36.7	36.3	35.9	35.4	35.0	34.6
52	39.0	38.6	38.3	37.9	37.5	37.1	36.7	36.3	35.9	35.5
53	39.8	39.4	39.0	38.6	38.2	37.8	37.4	37.1	36.7	36.3
54	40.6	40.2	39.8	39.4	39.0	38.6	38.2	37.8	37.4	37.0
55	41.4	41.0	40.6	40.2	39.8	39.4	39.0	38.6	38.2	37.8
56	42.2	41.8	41.3	40.9	40.5	40.1	39.7	39.3	38.9	38.5
57	43.0	42.6	42.1	41.7	41.3	40.9	40.5	40.1	39.7	39.3
58	43.9	43.4	43.0	42.5	42.1	41.7	41.3	40.9	40.5	40.1
59	44.8	44.3	43.9	43.4	42.9	42.5	42.1	41.6	41.2	40.8
60	45.8	45.3	44.7	44.2	43.7	43.3	42.9	42.4	42.0	41.6
61	46.8	46.3	45.7	45.2	44.7	44.2	43.7	43.3	42.8	42.3
62	47.8	47.3	46.7	46.2	45.7	45.2	44.7	44.1	43.6	43.1
63	48.8	48.3	47.7	47.2	46.7	46.2	45.7	45.1	44.6	44.1
64	49.8	49.3	48.8	48.3	47.8	47.3	46.7	46.2	45.6	45.1
65	50.8	50.3	49.9	49.4	48.9	48.4	47.8	47.3	46.7	46.2
66	51.8	51.4	50.9	50.5	50.0	49.5	48.9	48.4	47.8	47.3
67	52.8	52.4	51.9	51.5	51.0	50.5	50.0	49.4	48.9	48.4
68	53.8	53.4	52.9	52.5	52.0	51.5	51.0	50.6	50.1	49.6
69	54.8	54.4	53.9	53.5	53.0	52.5	52.0	51.6	51.1	50.6
70	55.8	55.4	54.9	54.5	54.0	53.5	53.0	52.6	52.1	51.6

TRUE PER CENT.

Ind. 71 to 135. Temp. 91° to 100°.

Indication.	TEMPERATURES.									
	91°	92°	93°	94°	95°	96°	97°	98°	99°	100°
71	56.8	56.4	55.9	55.5	55.0	54.5	54.1	53.6	53.2	52.7
72	57.8	57.4	56.9	56.5	56.0	55.5	55.1	54.6	54.2	53.7
73	58.8	58.4	57.9	57.5	57.0	56.5	56.1	55.6	55.2	54.7
74	59.9	59.5	59.0	58.6	58.1	57.6	57.1	56.7	56.2	55.7
75	60.9	60.5	60.0	59.6	59.1	58.6	58.1	57.7	57.2	56.7
76	61.9	61.5	61.0	60.6	60.1	59.6	59.1	58.7	58.2	57.7
77	63.0	62.5	62.1	61.6	61.2	60.7	60.2	59.8	59.3	58.8
78	64.0	63.5	63.1	62.6	62.2	61.7	61.2	60.8	60.3	59.8
79	65.0	64.6	64.1	63.7	63.2	62.7	62.3	61.8	61.4	60.9
80	66.0	65.6	65.1	64.7	64.2	63.7	63.3	62.8	62.4	61.9
81	67.0	66.6	66.1	65.7	65.2	64.7	64.3	63.8	63.4	62.9
82	68.0	67.6	67.1	66.7	66.2	65.8	65.3	64.9	64.4	64.0
83	69.0	68.6	68.1	67.7	67.2	66.8	66.3	65.9	65.4	65.0
84	70.1	69.6	69.2	68.7	68.3	67.8	67.4	66.9	66.5	66.0
85	71.1	70.6	70.2	69.7	69.3	68.9	68.4	68.0	67.5	67.1
86	72.1	71.6	71.2	70.7	70.3	69.9	69.4	69.0	68.5	68.1
87	73.1	72.6	72.2	71.7	71.3	70.9	70.4	70.0	69.5	69.1
88	74.1	73.6	73.2	72.7	72.3	71.9	71.4	71.0	70.5	70.1
89	75.1	74.6	74.2	73.7	73.3	72.9	72.4	72.0	71.5	71.1
90	76.1	75.6	75.2	74.7	74.3	73.9	73.4	73.0	72.5	72.1
91	77.1	76.7	76.2	75.8	75.3	74.9	74.4	74.0	73.5	73.1
92	78.2	77.7	77.3	76.8	76.3	75.9	75.4	75.0	74.5	74.1
93	79.3	78.8	78.4	77.9	77.4	76.9	76.5	76.0	75.6	75.1
94	80.4	79.9	79.5	79.0	78.5	78.0	77.5	77.1	76.6	76.1
95	81.5	81.0	80.6	80.1	79.7	79.2	78.7	78.2	77.7	77.2
96	82.6	82.1	81.7	81.2	80.8	80.3	79.8	79.3	78.8	78.3
97	83.6	83.1	82.7	82.2	81.8	81.3	80.9	80.4	80.8	79.5
98	84.6	84.1	83.7	83.2	82.8	82.4	81.9	81.5	81.0	80.6
99	85.6	85.1	84.7	84.2	83.8	83.4	83.0	82.5	82.1	81.7
100	86.6	86.1	85.7	85.2	84.8	84.4	84.0	83.5	83.1	82.7
101	87.6	87.1	86.7	86.2	85.8	85.4	85.0	84.5	84.1	83.7
102	88.7	88.2	87.8	87.3	86.9	86.5	86.0	85.6	85.1	84.7
103	89.7	89.3	88.8	88.4	87.9	87.5	87.0	86.6	86.1	85.7
104	90.8	90.4	89.9	89.5	89.0	88.5	88.1	87.6	87.2	86.7
105	91.9	91.4	91.0	90.5	90.1	89.6	89.2	88.7	88.3	87.8
106	93.0	92.5	92.1	91.6	91.2	90.7	90.3	89.8	89.4	88.9
107	94.0	93.6	93.1	92.7	92.3	91.8	91.4	90.9	90.5	90.0
108	95.1	94.6	94.2	93.7	93.3	92.9	92.4	92.0	91.5	91.1
109	96.1	95.6	95.2	94.7	94.3	93.9	93.5	93.0	92.6	92.2
110	97.2	96.7	96.3	95.8	95.4	95.0	94.5	94.1	93.6	93.2
111	98.2	97.7	97.3	96.8	96.4	96.0	95.6	95.1	94.7	94.3
112	99.3	98.8	98.4	97.9	97.5	97.1	96.6	96.2	95.7	95.3
113	100.3	99.8	99.4	98.9	98.5	98.1	97.7	97.2	96.8	96.4
114	101.4	100.9	100.5	100.0	99.6	99.2	98.8	98.3	97.9	97.5
115	102.4	102.0	101.5	101.1	100.7	100.3	99.8	99.4	98.9	98.5
116	103.4	103.0	102.5	102.1	101.7	101.3	100.9	100.4	100.0	99.6
117	104.4	104.0	103.6	103.2	102.8	102.4	102.0	101.5	101.1	100.7
118	105.5	105.1	104.6	104.2	103.8	103.4	103.0	102.5	102.1	101.7
119	106.5	106.1	105.6	105.2	104.8	104.4	104.0	103.6	103.2	102.8
120	107.5	107.1	106.7	106.3	105.9	105.5	105.1	104.6	104.2	103.8
121	108.5	108.1	107.7	107.3	106.9	106.5	106.1	105.6	105.2	104.8
122	109.5	109.1	108.7	108.3	107.9	107.5	107.1	106.7	106.3	105.9
123	110.6	110.2	109.7	109.3	108.9	108.5	108.1	107.7	107.3	106.9
124	111.7	111.2	110.8	110.3	109.9	109.5	109.1	108.7	108.3	107.9
125	112.7	112.3	111.8	111.4	111.0	110.6	110.2	109.7	109.3	108.9
126	113.8	113.4	112.9	112.5	112.1	111.7	111.2	110.8	110.3	109.9
127	114.8	114.4	114.0	113.6	113.2	112.8	112.3	111.9	111.4	111.0
128	115.9	115.5	115.0	114.6	114.2	113.8	113.3	112.9	112.4	112.0
129	116.9	116.5	116.0	115.6	115.2	114.8	114.4	113.9	113.5	113.1
130	117.9	117.5	117.1	116.7	116.3	115.9	115.5	115.0	114.6	114.2
131	118.9	118.5	118.1	117.7	117.3	116.9	116.5	116.1	115.7	115.3
132	119.9	119.5	119.2	118.8	118.4	118.0	117.6	117.2	116.8	116.4
133	121.0	120.6	120.2	119.8	119.4	119.0	118.6	118.2	117.8	117.4
134	122.0	121.6	121.2	120.8	120.4	120.0	119.6	119.2	118.8	118.4
135	123.0	122.6	122.2	121.8	121.4	121.0	120.6	120.2	119.8	119.4

TRUE PER CENT.

Ind. 136 to 200. Temp. 91° to 100°.

Indication.	TEMPERATURES.									
	91°	92°	93°	94°	95°	96°	97°	98°	99°	100°
136	124.0	123.6	123.2	122.8	122.4	122.0	121.6	121.2	120.8	120.4
137	125.1	124.7	124.3	123.9	123.5	123.1	122.7	122 3	121.9	121.5
138	126.2	125.8	125.3	124.9	124.5	124.1	123.7	123.3	122.9	122.5
139	127.3	126.9	126.4	126.0	125.6	125.2	124.8	124.3	123.9	123.5
140	128.4	128.0	127.5	127.1	126.7	126.3	125.9	125.4	125.0	124.6
141	129.4	129.0	128.6	128.2	127.8	127.4	127.0	126.5	126.1	125.7
142	130.5	130.1	129.7	129.3	128.9	128.5	128.1	127.6	127.2	126.8
143	131.5	131.1	130.7	130.3	129.9	129.5	129.1	128.7	128.3	127.9
144	132.5	132.1	131.8	131.4	131.0	130.6	130.2	129.8	129.4	129.0
145	133.5	133.1	132.8	132.4	132.0	131.6	131.2	130.9	130.5	130.1
146	134.5	134.1	133.8	133.4	133.0	132.6	132.2	131.9	131.5	131.1
147	135.5	135.2	134.8	134.5	134.1	133.7	133.3	132.9	132.5	132.1
148	136.6	136.2	135.9	135.5	135.1	134.7	134.3	134.0	133.6	133.2
149	137.6	137.2	136.9	136.5	136.1	135.7	135.3	135.0	134.6	134.2
150	138.7	138.3	138.0	137.6	137.2	136.8	136.4	136.0	135.6	135.2
151	139.7	139.3	139.0	138.6	138.2	137.8	137.4	137.1	136.7	136.3
152	140.8	140.4	140.1	139.7	139.3	138.9	138.5	138.1	137.7	137.3
153	141.8	141.4	141.1	140.7	140.3	139.9	139.5	139.1	138.7	138.3
154	142.9	142.5	142.2	141.8	141.4	141.0	140.6	140.2	139.8	139.4
155	143.9	143.5	143.2	142.8	142.4	142.0	141.6	141.3	140.9	140.5
156	145.0	144.6	144.3	143.9	143.5	143.1	142.7	142.4	142.0	141.6
157	146.0	145.7	145.3	145.0	144.6	144.2	143.8	143.5	143.1	142.7
158	147.1	146.7	146.4	146.0	145.6	145.2	144.8	144.5	144.1	143.7
159	148.1	147.8	147.4	147.1	146.7	146.3	145.9	145.6	145.2	144.8
160	149.2	148.9	148.5	148.2	147.8	147.4	147.0	146.7	146.3	145.9
161	150.2	149.9	149.5	149.2	148.8	148.4	148.1	147.7	147.4	147.0
162	151.3	151.0	150.6	150.3	149.9	149.5	149.2	148.8	148.5	148.1
163	152.4	152.1	151.7	151.4	151.0	150.6	150.2	149.9	149.5	149.1
164	153.4	153.1	152.7	152.4	152.0	151.6	151.3	150.9	150.6	150.2
165	154.5	154.2	153.8	153.5	153.1	152.7	152.4	152.0	151.7	151.3
166	155.5	155.2	154.8	154.5	154.1	153.7	153.4	153.0	152.7	152.3
167	156.6	156.3	155.9	155.6	155.2	154.8	154.5	154.1	153.8	153.4
168	157.7	157.3	157.0	156.6	156.3	155.9	155.6	155.2	154.9	154.5
169	158.7	158.4	158.0	157.7	157.3	157.0	156.6	156.3	155.9	155.6
170	159.8	159.4	159.1	158.7	158.4	158.0	157.7	157.3	157.0	156.6
171	160.8	160.5	160.1	159.8	159.4	159.1	158.7	158.4	158.0	157.7
172	161.9	161.6	161.2	160.9	160.5	160.2	159.8	159.5	159.1	158.8
173	163.0	162.6	162.3	161.9	161.6	161.3	160.9	160.6	160.2	159.9
174	164.1	163.7	163.4	163.0	162.7	162.4	162.0	161.7	161.3	161.0
175	165.2	164.8	164.5	164.1	163.8	163.5	163.1	162.8	162.4	162.1
176	166.3	165.9	165.6	165.2	164.9	164.6	164.2	163.9	163.5	163.2
177	167.4	167.0	166.7	166.3	166.0	165.7	165.4	165.0	164.7	164.4
178	168.5	168.1	167.8	167.4	167.1	166.8	166.5	166.1	165.8	165.5
179	169.6	169.3	168.9	168.6	168.3	168.0	167.6	167.3	166.9	166.6
180	170.7	170.4	170.0	169.7	169.4	169.1	168.7	168.4	168.0	167.7
181	171.8	171.5	171.1	170.8	170.5	170.2	169.9	169.5	169.2	168.9
182	172.9	172.6	172.2	171.9	171.6	171.3	171.0	170.6	170.3	170.0
183	174.0	173.7	173.3	173.0	172.7	172.4	172.1	171.7	171.4	171.1
184	175.1	174.8	174.4	174.1	173.8	173.5	173.2	172.8	172.5	172.2
185	176.1	175.8	175.5	175.2	174.9	174.6	174.3	173.9	173.6	173.3
186	177.2	176.9	176.6	176.3	176.0	175.7	175.4	175.0	174.7	174.4
187	178.3	178.0	177.8	177.5	177.2	176.9	176.6	176.2	175.9	175.6
188	179.5	179.2	178.9	178.6	178.3	178.0	177.7	177.4	177.1	176.8
189	180.6	180.3	180.1	179.8	179.5	179.2	178.9	178.6	178.3	178.0
190	181.8	181.5	181.2	180.9	180.6	180.3	180.0	179.8	179.5	179.2
191	182.9	182.6	182.4	182.1	181.8	181.5	181.2	181.0	180.7	180.4
192	184.1	183.8	183.6	183.3	183.0	182.7	182.4	182.2	181.9	181.6
193	185.3	185.0	184.8	184.5	184.2	183.9	183.6	183.4	183.1	182.8
194	186.5	186.2	186.0	185.7	185.4	185.1	184.8	184.6	184.3	184.0
195	187.6	187.4	187.1	186.9	186.6	186.3	186.0	185.8	185.5	185.2
196	188.8	188.5	188.3	188.0	187.8	187.5	187.2	187.0	186.7	186.4
197	189.9	189.7	189.4	189.2	188.9	188.6	188.4	188.1	187.9	187.6
198	191.1	190.8	190.6	190.3	190.1	189.8	189.6	189.3	189.1	188.8
199	192.2	191.9	191.7	191.4	191.2	190.9	190.7	190.4	190.2	189.9
200	193.3	193.0	192.8	192.5	192.3	192.1	191.8	191.6	191.3	191.1

CORRECTIONS TO VOLUME.

This table gives the correction to 100 gallons of spirits, to be added when measured at temperatures below 60°, and to be subtracted when measured above 60° Fahrenheit.

True per cent.	TEMPERATURES.										
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
5	....	....	....	.08	.09	.07	0 0	.11	.25	.43	.63
10	....	....	....	.09	.10	.07	0.0	.11	.26	.45	.68
15	....	....	....	.11	.12	.08	0.0	.12	.28	.47	.71
20	....	....	....	.15	.14	.09	0.0	.13	.29	.50	.74
25	....	....	....	.20	.17	.10	0.0	.14	.32	.54	.80
30	....	....	....	.25	.20	.12	0.0	.16	.35	.58	.85
35	....	....	....	.32	.25	.14	0.0	.18	.39	.64	.93
40	....	....	....	.41	.31	.17	0.0	.20	.44	.71	1.02
45	....	....	....	.50	.36	.20	0.0	.23	.49	.77	1.09
50	....	....	....	.57	.41	.22	0.0	.24	.52	.82	1.14
55	1.11	.96	80	.66	.47	.24	0.0	.27	.56	.89	1.23
60	1.32	1 14	.96	.76	.53	.27	0.0	.29	.61	.95	1.30
65	1.52	1.31	1.09	.84	.58	.29	0.0	.32	.66	1.02	1.39
70	1.74	1.48	1.20	.93	.64	.33	0.0	.34	.71	1.09	1.48
75	1.95	1.65	1.37	1.02	.69	.35	0.0	.37	.75	1.16	1.56
80	2 10	1.78	1.45	1.08	.73	.37	0.0	.39	.79	1.20	1.63
85	2.22	1.87	1.52	1.14	.77	.39	0.0	.41	.83	1.26	1.70
90	2.32	1.95	1.58	1.19	.80	.41	0.0	.42	.86	1.30	1.77
95	2 42	2.03	1.64	1.23	.83	.42	0.0	.44	.88	1.34	1.81
100	2.50	2.09	1.69	1.27	.86	.43	0.0	.45	.91	1.38	1.86
105	2.56	2.14	1.73	1.31	.88	.45	0.0	.46	.93	1.41	1.91
110	2.63	2.20	1 77	1.34	.91	.46	0.0	.47	.95	1.45	1.96
115	2.68	2.25	1.81	1 37	.92	.47	0.0	.48	.97	1.47	1.99
120	2.73	2.29	1.85	1.39	.94	.48	0.0	.49	.98	1.50	2.02
125	2.78	2.34	1.88	1.42	.96	.48	0.0	.50	1.00	1.52	2.05
130	2 84	2.39	1.93	1.44	.97	.49	0.0	.51	1.02	1.53	2 08
135	2.89	2 43	1.96	1.48	.99	.50	0.0	.52	1 04	1.57	2 12
140	2.94	2.47	1.99	1.49	1.01	.51	0.0	.52	1.05	1.60	2 15
145	3.00	2.51	2.03	1.51	1.02	.51	0.0	.53	1.06	1.61	2.17
150	3.05	2.55	2.06	1.54	1.03	.52	0.0	.53	1.08	1.63	2.20
155	3 09	2.59	2.09	1.55	1.05	.53	0.0	.54	1.09	1.65	2.22
160	3.14	2.62	2.11	1 59	1.07	.54	0.0	55	1.11	1.67	2.25
165	3.18	2.66	2.14	1.62	1.08	.55	0.0	.55	1.12	1.69	2.27
170	3.22	2.69	2.18	1.64	1.10	.55	0.0	.56	1.13	1.71	2.29
175	3.25	2.72	2.21	1.66	1.11	.56	0.0	.57	1.14	1.73	2 32
180	3.29	2.76	2 23	1.68	1.12	.57	0.0	.58	1.16	1.75	2.35
185	3.34	2.80	2.26	1.69	1.13	.57	0.0	.58	1.17	1.77	2.38
190	3.38	2.83	2.28	1.71	1.15	.58	0.0	.59	1.18	1.80	2.42
195	3.42	2.86	2.31	1.72	1.16	.59	0.0	.59	1.20	1.82	2.44
200	3.46	2.90	2.33	1.74	1.18	.60	0.0	.60	1.21	1.84	2.46

TABLE II.—*For finding the number of gallons at 60° Fahr. from the weight and strength of spirituous liquor.*

EXAMPLE.—A cask of spirits of 141 per cent. strength (or 41 above proof), weighed 913 pounds. We find

900 pounds	=	121.54 gallons.		
10	"	=	1 35 gallon.	
3	"	=	0.40	"
or contents, .			123.29	

supposed to be measured at 60° Fahr.

The equivalent gallons for 10 pounds are found from the column 100 pounds by moving the decimal point one place to the left; those for 3 pounds from the column 300 pounds by moving the decimal point two places to the left.

GALLONS BY WEIGHT AND STRENGTH OF SPIRIT.

Per cent.	Pounds.									
	100	200	300	400	500	600	700	800	900	1000
	Galls.	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*
2	12.02	24.04	36.06	48 08	60.10	72 12	84.14	96.16	108 18	120.20
4	.04	.07	.11	.15	.18	.22	.26	.30	.33	.37
6	.05	.11	.16	.22	.27	.32	.38	.43	.49	.54
8	.07	.14	.21	.29	.36	.43	.50	.57	.64	.71
10	.09	.18	.27	.35	.44	.53	.62	.71	.80	.89
12	12.10	24.21	36.31	48.42	60.52	72.63	84.73	96.84	108.94	121.04
14	.12	.24	.36	.48	.60	.72	.84	.96	109.08	.20
16	.13	.27	.40	.54	.67	.81	.94	97.08	.21	.35
18	.15	.30	.45	.60	.75	.90	85.05	.20	.35	.50
20	.17	.33	.50	.66	.83	.99	.16	.32	.49	.65
22	12.18	24.36	36 54	48.72	60.90	73.07	85.25	97.43	109.61	121.79
24	.19	.39	.58	.77	.96	.16	.35	.54	.74	.93
26	.21	.41	.62	.83	61.03	.24	.45	.65	.86	122.07
28	.22	.44	.66	.88	.10	.32	.54	.76	.98	.20
30	.23	.47	.70	.93	.17	.40	.63	.87	110.10	.34
32	12.25	24.49	36.74	48.99	61.23	73.48	85.72	97.97	110.22	122.46
34	.26	.52	.78	49.04	.30	.56	.82	98 07	.33	.59
36	.27	.54	.82	.09	.36	.63	.91	.18	.45	.72
38	.29	.57	.86	.14	.43	.71	86.00	.28	.57	.85
40	.30	.60	.89	.19	.49	.79	.09	.38	.68	.98
42	12.31	24.62	36.93	49.24	61.55	73.86	86.18	98.49	110.80	123.11
44	.32	.65	.97	.29	.62	.94	.27	.59	.91	.24
46	.34	.67	37.01	.35	.68	74.02	.36	.70	111.03	.37
48	.35	.70	.05	.40	.75	.10	.45	.80	.15	.50
50	.36	.73	.09	.45	.81	.18	.54	.90	.27	.63
52	12 38	24.75	37.13	49.51	61.88	74.26	86.64	99.01	111.39	123.76
54	.39	.78	.17	.56	.95	.34	.73	.12	.51	.90
56	.40	.81	.21	.61	62 02	.42	.83	.23	.63	124.04
58	.42	.84	.25	.67	.09	.51	.93	.35	.76	.18
60	.43	.87	.30	.73	.16	.60	87.03	.46	.90	.33
62	12.45	24.90	37.34	49.79	62.24	74.69	87.13	99.58	112.03	124.48
64	.46	.93	.39	.85	.32	.78	.25	.71	.17	.64
66	.48	.96	.44	.92	.40	.88	.36	.84	.32	.80
68	.50	.99	.49	.99	.48	.98	.48	.97	.47	.97
70	.51	25.03	.54	50.06	.57	75.08	.60	100.11	.63	125.14
72	12 53	25.06	37.60	50.13	62.66	75.19	87.72	100.25	112 79	125 32
74	.55	.10	.65	.20	.75	.30	.85	.40	.96	.51
76	.57	.14	.71	.28	.85	.42	.99	.56	113.12	.69
78	.59	.18	.77	.36	.95	.54	88 12	.71	.30	.89
80	.61	.22	.83	.44	63.05	.65	.26	.87	.48	126 09
82	12.63	25.26	37.89	50.52	63.15	75.78	88.41	101.04	113.67	126 30
84	.65	.30	.96	.61	.26	.91	.56	.22	.87	.52
86	.67	.35	38.02	.70	.37	76.05	.72	.40	114.07	.74
88	.70	.39	.09	.79	.49	.18	.88	.58	.27	.97
90	.72	.44	.16	.88	.60	.32	89.04	.76	.48	127.20
92	12.74	25.49	38.23	50.98	63.72	76.46	89 21	101.95	114.70	127.44
94	.77	.54	.31	51.07	.84	.61	.38	102.15	.92	.69
96	.79	.59	.38	.18	.97	.76	.56	.35	115.15	.94
98	.82	.64	.46	.28	64.10	.92	.74	.56	.38	128 20
100	.85	.69	.54	.38	23	77.08	.92	.77	.61	.46

Water 100 pounds = 12.00 gallons.

Table II.—Continued.

GALLONS BY WEIGHT AND STRENGTH OF SPIRIT.

Per cent.	Pounds.									
	100	200	300	400	500	600	700	800	900	1000
	Galls.	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*
101	12.86	25.72	38.58	51.44	64.30	77.15	90 01	102.87	115.73	128.59
102	.87	.74	.62	.49	.36	.23	.11	.98	.85	.72
103	.89	.77	.66	.55	.43	.32	.20	103 09	.98	.86
104	.90	.80	.70	.60	.50	.40	.30	.20	116.10	129.00
105	.91	.83	.74	.66	.57	.49	.40	.32	.23	.14
106	12.93	25.86	38.79	51.71	64.64	77.57	90.50	103.43	116.36	129.29
107	.94	.89	.83	.77	.71	.66	.60	.54	.49	.43
108	.96	.91	.87	.83	.79	.74	.70	.66	.61	.57
109	.97	.94	.91	.89	.86	.83	.80	.77	.74	.72
110	.99	.97	.96	.94	.93	.92	.90	.89	.88	.86
111	13.00	26.00	39.00	52.00	65.01	78.01	91.01	104 01	117 01	130.01
112	.02	.03	.05	.06	.08	.09	.11	.13	.14	.16
113	.03	.06	.09	.12	.15	.19	.22	.25	.28	.31
114	.05	.09	.14	.18	.23	.28	.32	.37	.41	.46
115	.06	.12	.18	.25	.31	.37	.43	.49	.55	.61
116	13.08	26.15	39.23	52 31	65.38	78.46	91.54	104.61	117.69	130.77
117	.09	.18	.28	.37	.46	.55	.65	.74	.83	.92
118	.11	.22	.32	.43	.54	.65	.76	.86	.97	131.08
119	.12	.25	.37	.50	.62	.74	.87	.99	118.11	.24
120	.14	.28	.42	.56	.70	.84	.98	105.12	.26	.40
121	13.16	26.31	39.47	52.62	65.78	78.94	92.09	105.25	118.40	131.56
122	.17	.34	.52	.69	.86	79.03	.21	.38	.55	.72
123	.19	.38	.57	.75	.94	.13	.32	.51	.70	.88
124	.20	.41	.61	.82	66.02	.23	.43	.64	.84	132.05
125	.22	.44	.66	.89	.11	.33	.55	.77	.99	.21
126	13 24	26.48	39.71	52.95	66.19	79.43	92 66	105.90	119.14	132.38
127	.25	.51	.76	53.02	.27	.53	.78	106.04	.29	.55
128	.27	.54	.81	.09	.36	.63	.90	.17	.44	.71
129	.29	.58	.86	.15	.44	.73	93.02	.31	.59	.88
130	.31	.61	.92	.22	.53	.83	.14	44	.75	133.05
131	13.32	26.65	39.97	53.29	66.61	79.94	93.26	106.58	119.90	133.23
132	.34	.68	40.02	.36	.70	80.04	.38	.72	120.06	.40
133	.36	.72	.07	.43	.79	.15	.50	.86	.22	.58
134	.38	.75	.13	.50	.88	.25	.63	107.00	.38	.76
135	.39	.79	.18	.57	.97	.36	.75	.15	.54	.94
136	13.41	26.82	40.24	53.65	67.06	80.47	93.88	107.29	120.71	134.12
137	.43	.86	.29	.72	.15	.58	94.01	.44	.87	.30
138	.45	.90	.34	.79	.24	.69	.14	.58	121.03	.48
139	.47	.94	.40	.87	.34	.81	.27	.74	.21	.68
140	.49	.97	.46	.94	.43	.91	.40	.89	.37	.86
141	13.50	27.01	40.51	54.02	67.52	81.03	94.53	108.04	121.54	135.05
142	.52	.05	.57	.10	.62	.14	.67	.19	.71	.24
143	.54	.09	.63	.17	.72	.26	.80	.34	.89	.43
144	.56	.12	.69	.25	.81	.37	.94	.50	122.06	.62
145	.58	.16	.75	.33	.91	.49	95.07	.65	.24	.82
146	13.60	27.20	40.80	54.41	68.01	81.61	95.21	108.81	122.41	136.01
147	.62	.24	.86	.48	.11	.73	.35	.97	.59	.21
148	.64	.28	.92	.56	.21	.85	.49	109.13	.77	.41
149	.66	.32	.98	.65	.31	.97	.63	.29	.95	.61
150	.68	.36	41.04	.73	.41	82.09	.77	.45	123.13	.82
151	13.70	27.40	41.11	54.81	68.51	82.21	95.91	109.62	123.32	137.02
152	.72	.45	.17	.89	.61	.34	96.06	.78	.50	.23
153	.74	.49	.23	.97	.72	.46	.20	.95	.69	.44
154	.76	.53	.29	55.06	.82	.59	.35	110 12	.88	.65
155	.79	.57	.36	.14	.93	.71	.50	.29	124.07	86
156	13.81	27.61	41.42	55.23	69.03	82.84	96.65	110.46	124.26	138.07
157	.83	.66	.49	.31	.14	.97	.80	.63	.46	.29
158	.85	.70	.55	.40	.25	83.10	.95	.80	.66	.51
159	.87	.75	.62	.49	.36	.24	97.11	.98	.85	.73
160	.89	.79	.68	.58	.47	.37	.26	111.16	125.05	.95

Water 100 pounds = 12.00 gallons.

TABLE II.—Continued.

GALLONS BY WEIGHT AND STRENGTH OF SPIRIT.

Per cent.	Pounds.									
	100	200	300	400	500	600	700	800	900	1000
	Galls.	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*
161	13.92	27.83	41.75	55.67	69.59	83.50	97.42	111.34	125.26	139.17
162	.94	.88	.82	76	.70	.64	.58	.52	.46	.40
163	.96	.93	.89	.85	.81	.78	.74	.70	.67	.63
164	.99	.97	.96	.94	.93	.92	.90	.89	.87	.86
165	14.01	28.02	42.03	56.04	70.05	84.06	98.06	112.07	126.08	140.09
166	14.03	28.07	42.10	56.13	70.16	84.20	98.23	112.26	126.29	140.33
167	.06	.11	.17	.23	.28	.34	.40	.45	.51	.56
168	.08	.16	.24	.32	.40	.48	.56	64	72	.80
169	.10	.21	.31	.42	.52	.63	.73	.84	.94	141.04
170	.13	.26	.39	.52	.65	.78	.90	113.03	127.16	29
171	14.15	28.31	42.46	56.61	70.77	84.92	99.08	113.23	127.38	141.54
172	.18	.36	.53	.71	.89	85.07	.25	.43	.60	78
173	.20	.41	.61	.82	71.02	.22	.43	.63	84	142.04
174	.23	.46	.69	.92	.15	.38	.61	.84	128.07	30
175	.26	.51	.77	57.03	.28	.54	.80	114.06	.31	.57
176	14.28	28.57	42.85	57.14	71.42	85.70	99.99	114.27	128.55	142.84
177	.31	.62	.93	.24	.55	.86	100.17	.49	.80	143.11
178	.34	68	43.01	.35	.69	86.03	.36	.70	129.04	.38
179	.37	.73	.10	.46	.83	.20	.56	93	.29	66
180	.39	.79	.18	.58	.97	.37	.76	115.16	.55	.94
181	14.42	28.85	43.27	57.69	72.12	86.54	100.97	115.39	129.81	144.24
182	.45	.91	.36	.81	.27	.72	101.17	.63	130.08	53
183	.48	.97	.45	.93	.41	.90	.38	.86	.35	83
184	.51	29.03	.54	58.05	.56	87.08	.58	116.10	.61	145.13
185	.54	.09	.63	.18	.72	.26	.81	.35	.91	.44
186	14.58	29.15	43.73	58.30	72.88	87.45	102.03	116.61	131.18	145.76
187	.61	.22	.82	.43	73.04	.65	.26	.87	.47	146.08
188	.64	.28	.92	.56	.20	.85	.49	117.13	.77	.41
189	.68	.35	44.03	.70	.38	88.05	.73	.40	132.08	75
190	.71	.42	.13	.84	.55	.26	.97	.68	39	147.10
191	14.75	29.49	44.24	58.99	73.73	88.48	193.23	117.97	132.72	147.47
192	.78	.57	.35	59.13	.92	.70	.48	118.27	133.05	.84
193	.82	.64	.46	.29	74.11	.93	.75	.57	.39	148.21
194	.86	.72	.58	.44	.30	89.16	104.02	.87	.73	.59
195	.90	.80	.69	.59	.49	.39	.29	119.18	134.08	.98
196	14.94	29.87	44.81	59.75	74.69	89.62	104.56	119.50	134.43	149.37
197	.98	.96	.93	.91	.89	.87	.84	.82	.80	.78
198	15.02	30.04	45.06	60.08	75.09	90.11	105.13	120.15	135.17	150.19
199	.06	.12	.19	.25	.31	.37	.43	.49	.56	.62
200	.11	.21	.32	42	.53	.64	.74	.85	.95	151.06

Water 100 pounds = 12.00 gallons.

TABLE III.—*Giving the respective volumes of absolute alcohol and water contained in 100 volumes of spirits of different strengths, and the specific gravities, referred to water at 60° as unity.*

RESPECTIVE VOLUMES OF ALCOHOL AND WATER, AND SPECIFIC GRAVITY.

Per cent.	Alcohol.	Water.	Specific gravity.	Per cent.	Alcohol.	Water.	Specific gravity.
	Vols.	*Vols.*			*Vols.*	*Vols.*	
1	0.50	99.53	.99929	61	30.50	72.25	.96484
2	1.00	99.06	.99858	62	31.00	71.79	.96426
3	1.50	98.59	.99787	63	31.50	71.33	.96364
4	2.00	98.13	.99716	64	32.00	70.87	.96302
5	2.50	97.66	.99645	65	32.50	70.42	.96240
6	3.00	97.19	.99574	66	33.00	69.96	.96178
7	3.50	96.72	.99503	67	33.50	69.49	.96114
8	4.00	96.25	.99431	68	34.00	69.03	.96049
9	4.50	95.78	.99360	69	34.50	68.57	.95982
10	5.00	95.32	.99289	70	35.00	68.10	.95915
11	5.50	94.85	.99224	71	35.50	67.64	.95847
12	6.00	94.39	.99160	72	36.00	67.17	.95779
13	6.50	93.93	.99098	73	36.50	66.70	.95707
14	7.00	93.48	.99036	74	37.00	66.23	.95635
15	7.50	93.02	.98974	75	37.50	65.77	.95564
16	8.00	92.56	.98911	76	38.00	65.30	.95492
17	8.50	92.10	.98849	77	38.50	64.82	.95417
18	9.00	91.64	.98787	78	39.00	64.35	.95342
19	9.50	91.18	.98725	79	39.50	63.88	.95267
20	10.00	90.72	.98663	80	40.00	63.41	.95192
21	10.50	90.26	.98608	81	40.50	62.93	.95112
22	11.00	89.81	.98552	82	41.00	62.45	.95031
23	11.50	89.36	.98497	83	41.50	61.97	.94950
24	12.00	88.91	.98441	84	42.00	61.50	.94869
25	12.50	88.45	.98386	85	42.50	61.01	.94785
26	13.00	88.00	.98330	86	43.00	60.53	.94701
27	13.50	87.55	.98275	87	43.50	60.05	.94617
28	14.00	87.10	.98220	88	44.00	59.57	.94532
29	14.50	86.65	.98167	89	44.50	59.08	.94446
30	15.00	86.20	.98114	90	45.00	58.60	.94359
31	15.50	85.75	.98063	91	45.50	58.12	.94271
32	16.00	85.30	.98011	92	46.00	57.63	.94183
33	16.50	84.85	.97959	93	46.50	57.14	.94093
34	17.00	84.40	.97907	94	47.00	56.66	.94003
35	17.50	83.95	.97856	95	47.50	56.16	.93909
36	18.00	83.50	.97804	96	48.00	55.67	.93815
37	18.50	83.05	.97753	97	48.50	55.18	.93721
38	19.00	82.60	.97702	98	49.00	54.69	.93627
39	19.50	82.16	.97651	99	49.50	54.20	.93532
40	20.00	81.71	.97600	100	50.00	53.71	.93437
41	20.50	81.26	.97549	101	50.50	53.21	.93341
42	21.00	80.81	.97498	102	51.00	52.72	.93245
43	21.50	80.36	.97447	103	51.50	52.22	.93144
44	22.00	79.91	.97396	104	52.00	51.72	.93043
45	22.50	79.47	.97344	105	52.50	51.22	.92941
46	23.00	79.02	.97292	106	53.00	50.73	.92839
47	23.50	78.57	.97241	107	53.50	50.23	.92737
48	24.00	78.12	.97190	108	54.00	49.73	.92635
49	24.50	77.67	.97139	109	54.50	49.22	.92531
50	25.00	77.22	97087	110	55.00	48.72	.92427
51	25.50	76.77	.97034	111	55.50	48.22	.92322
52	26.00	76.32	.96981	112	56.00	47.72	.92217
53	26.50	75.87	.96928	113	56.50	47.22	.92111
54	27.00	75.42	.96874	114	57.00	46.71	.92004
55	27.50	74.97	.96821	115	57.50	46.21	.91896
56	28.00	74.52	.96767	116	58.00	45.70	.91788
57	28.50	74.06	.96711	117	58.50	45.19	.91679
58	29.00	73.61	.96655	118	59.00	44.69	.91569
59	29.50	73.16	.96598	119	59.50	44.18	.91458
60	30.00	72.70	.96541	120	60.00	43.67	.91346

TABLE III.—Continued.

RESPECTIVE VOLUMES OF ALCOHOL AND WATER, AND SPECIFIC GRAVITY.

Per cent.	Alcohol.	Water.	Specific gravity.	Per cent.	Alcohol.	Water.	Specific gravity.
	Vols.	*Vols.*			*Vols.*	*Vols.*	
121	60.50	43.16	.91234	161	80.50	22 28	.86244
122	61.00	42.65	.91122	162	81.00	21.74	.86104
123	61.50	42.14	.91010	163	81 50	21 20	.85962
124	62.00	41.63	.90897	164	82 00	20.66	.85820
125	62.50	41.12	.90784	165	82.50	20.12	.85678
126	63.00	40.61	.90671	166	83.00	19.58	.85535
127	63.50	40.10	.90556	167	83.50	19.04	.85390
128	64.00	39.59	.90441	168	84.00	18.50	.85245
129	64.50	39.07	.90326	169	84.50	17.95	.85098
130	65.00	38.56	.90211	170	85.00	17.41	.84950
131	65.50	38.05	.90093	171	85.50	16.86	.84803
132	66.00	37.53	.89975	172	86.00	16.32	.84656
133	66.50	37.01	.89856	173	86.50	15.77	.84502
134	67.00	36.50	.89737	174	87.00	15.22	.84347
135	67.50	35.98	.89616	175	87.50	14.66	.84189
136	68.00	35.46	.89495	176	88.00	14.11	.84031
137	68.50	34.94	.89375	177	88.50	13.55	.83873
138	69.00	34.42	.89254	178	89.00	12.99	.83715
139	69.50	33.90	.89129	179	89.50	12.43	.83550
140	70.00	33.38	.89003	180	90.00	11.87	.83385
141	70.50	32.86	.88878	181	90.50	11.30	.83216
142	71.00	32.33	.88753	182	91.00	10.74	.83046
143	71.50	31.81	.88627	183	91.50	10.17	.82876
144	72.00	31.29	.88500	184	92 00	9.60	.82706
145	72.50	30.76	.88374	185	92.50	9.03	.82527
146	73.00	30.24	.88247	186	93 00	8.45	.82348
147	73.50	29.71	.88119	187	93.50	7.87	.82165
148	74.00	29.19	.87990	188	94.00	7.29	.81981
149	74 50	28.66	.87860	189	94.50	6.70	.81790
150	75.00	28.	.87730	190	95.00	6.10	.81598
151	75.50	27.61	.87599	191	95.50	5.51	.81394
152	76.00	27.08	.87467	192	96.00	4.91	.81190
153	76.50	26.55	.87334	193	96.50	4.31	.80983
154	77.00	26.02	.87200	194	97.00	3.70	.80776
155	77.50	25.48	.87067	195	97.50	3.10	.80566
156	78.00	24.95	.86933	196	98.00	2.48	.80356
157	78.50	24.42	.86796	197	98.50	1.87	.80137
158	79.00	23.88	.86659	198	99.00	1.25	.79918
159	79.50	23.35	.86522	199	99.50	0 62	.79690
160	80.00	22.81	.86384	200	100.00	0.00	.79461

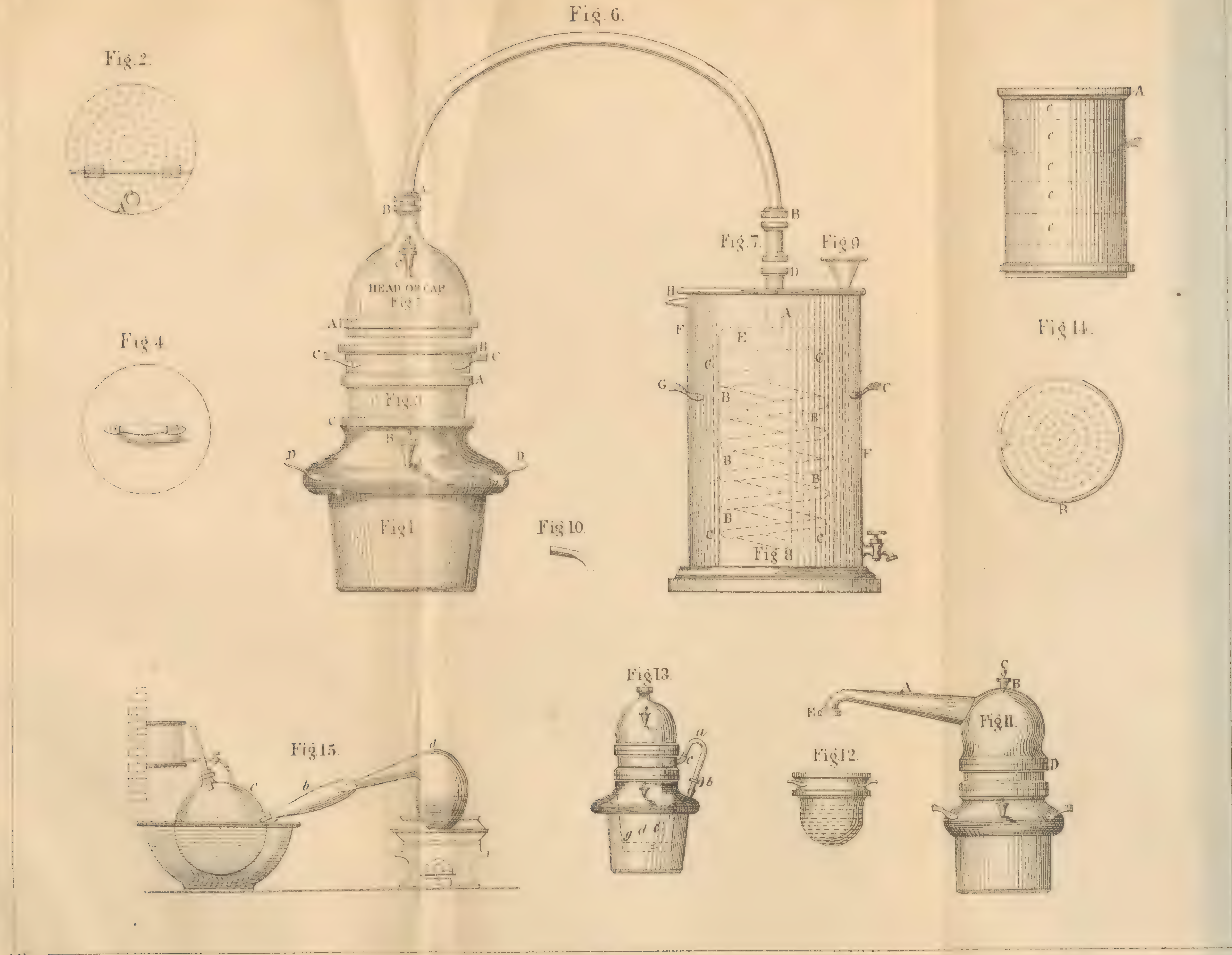


Fig.6.
Fig.2.
Fig.4
HEAD OR CAP
Fig.3
Fig.1
Fig.7.
Fig.9
Fig.8
Fig.10.
Fig.14.
Fig.15.
Fig.13.
Fig.12.
Fig.11.

Fig 1.

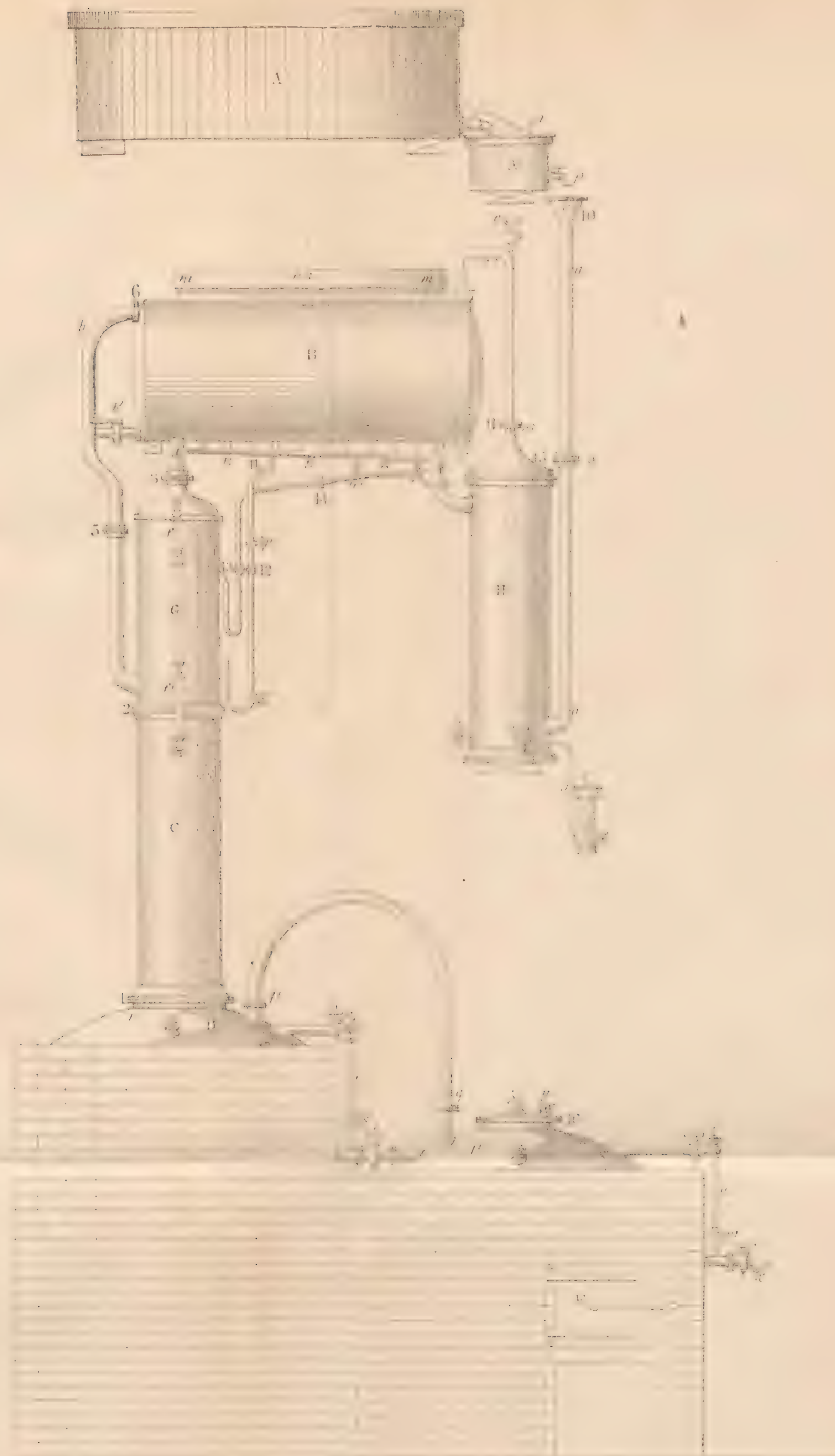


Fig 2

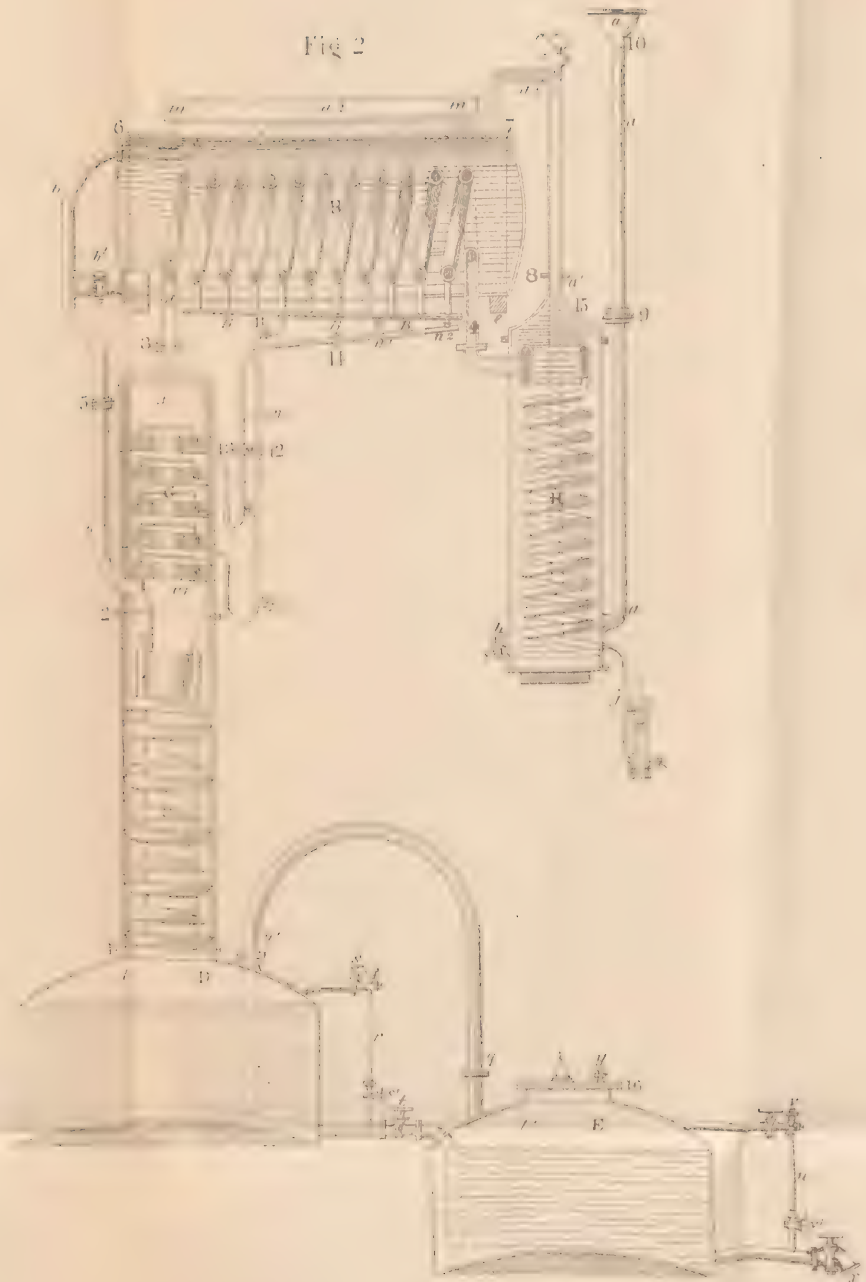
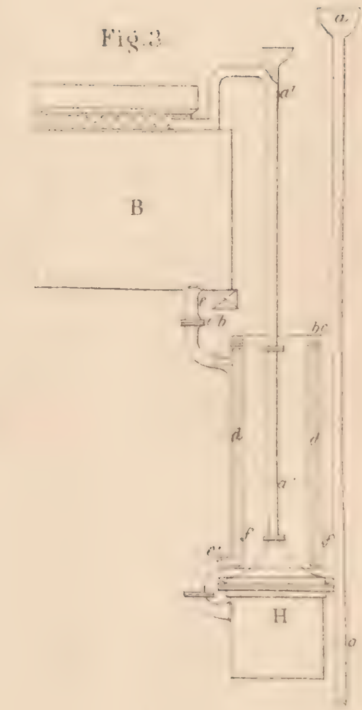


Fig.3



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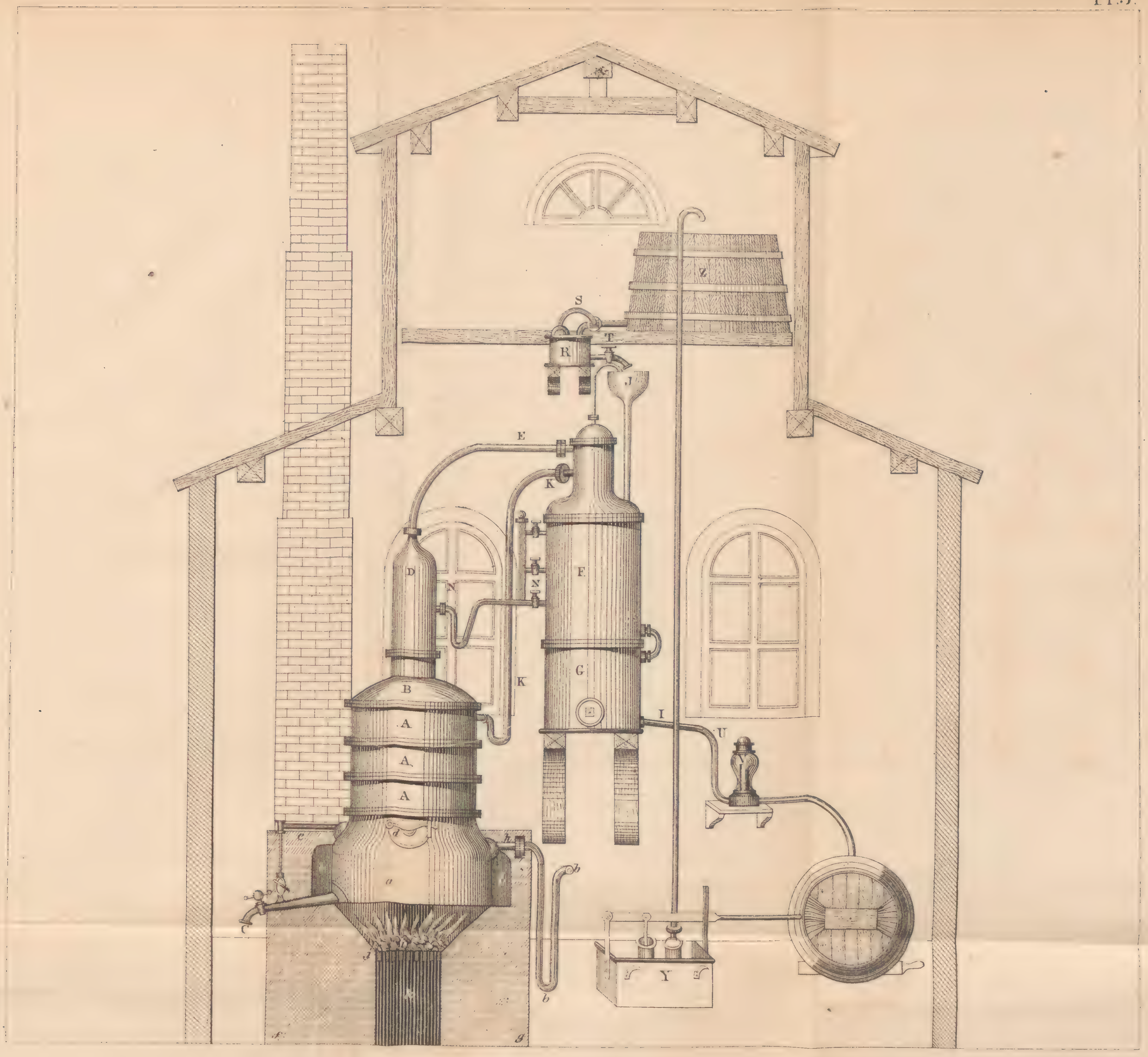
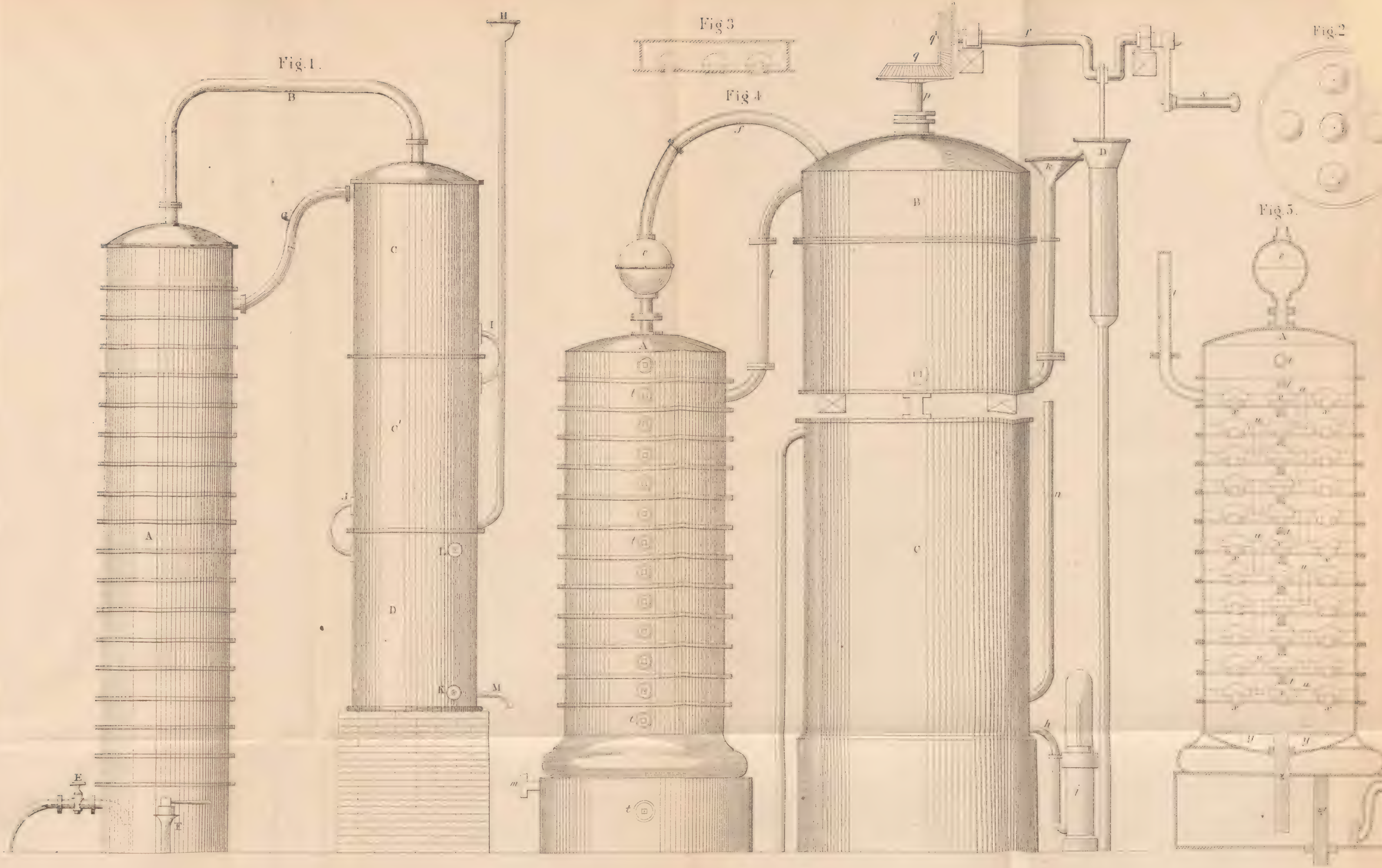




F. Bourquin Lith. Phila.

Fig. 1.

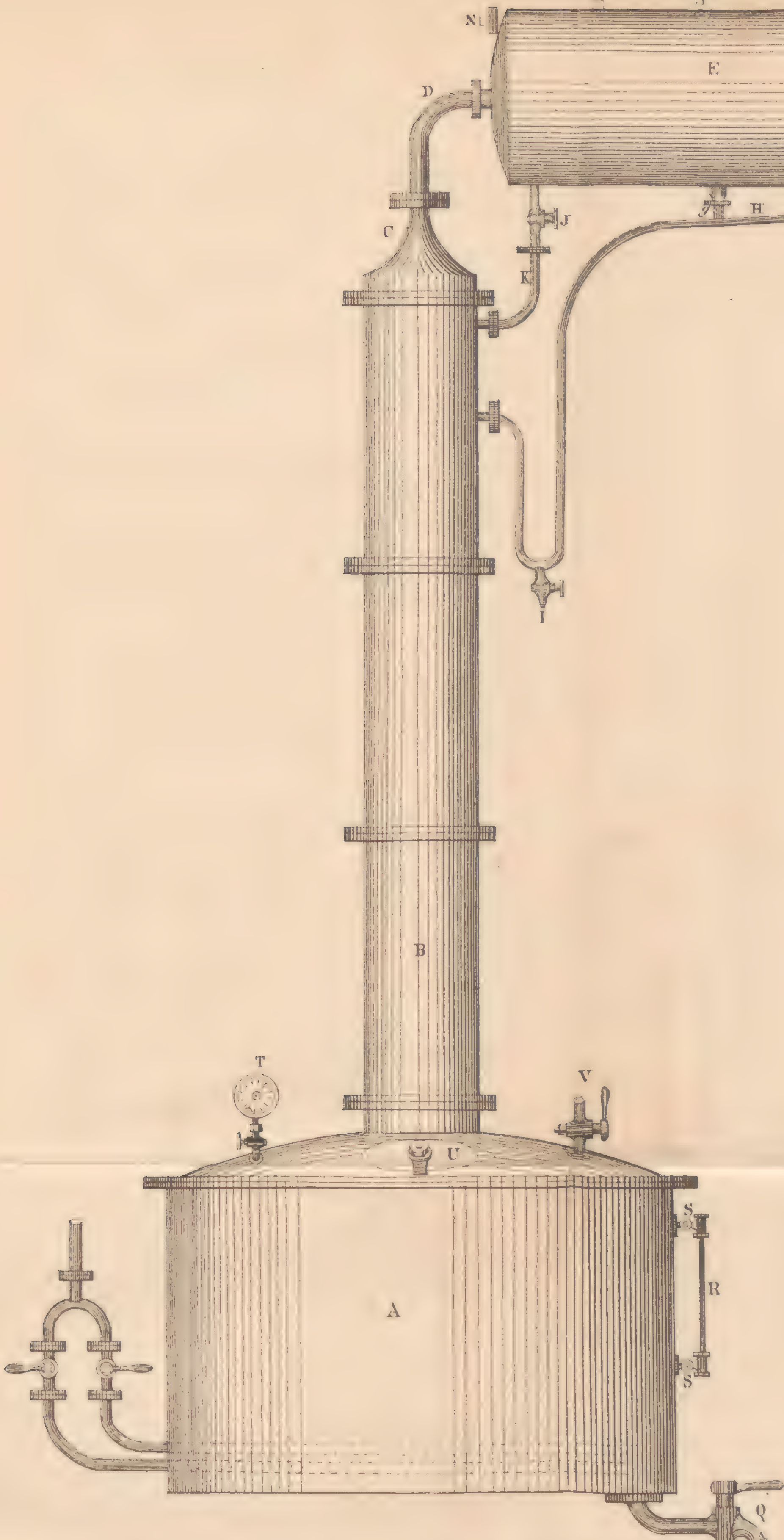


Fig. 2

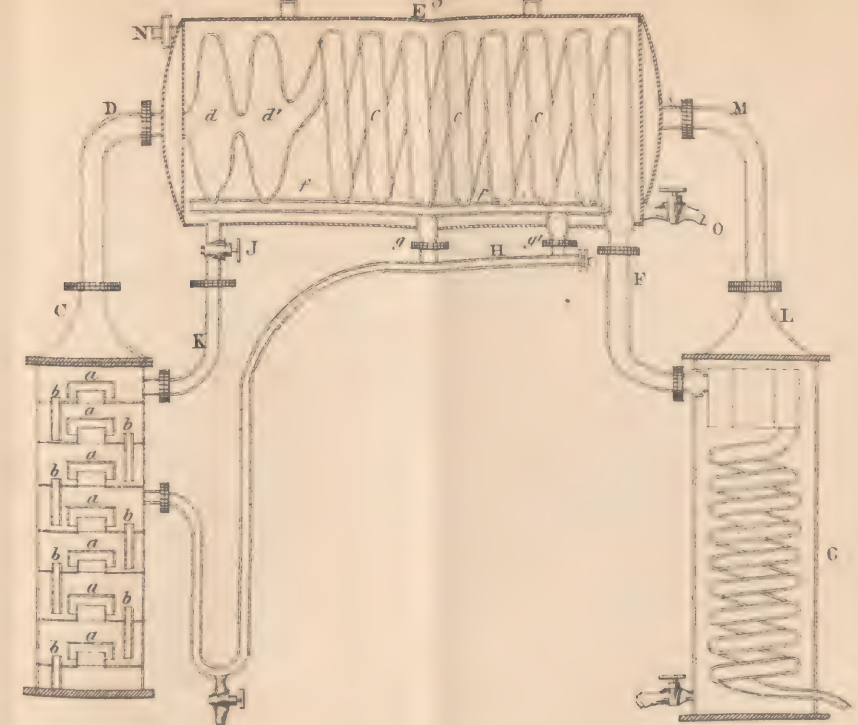
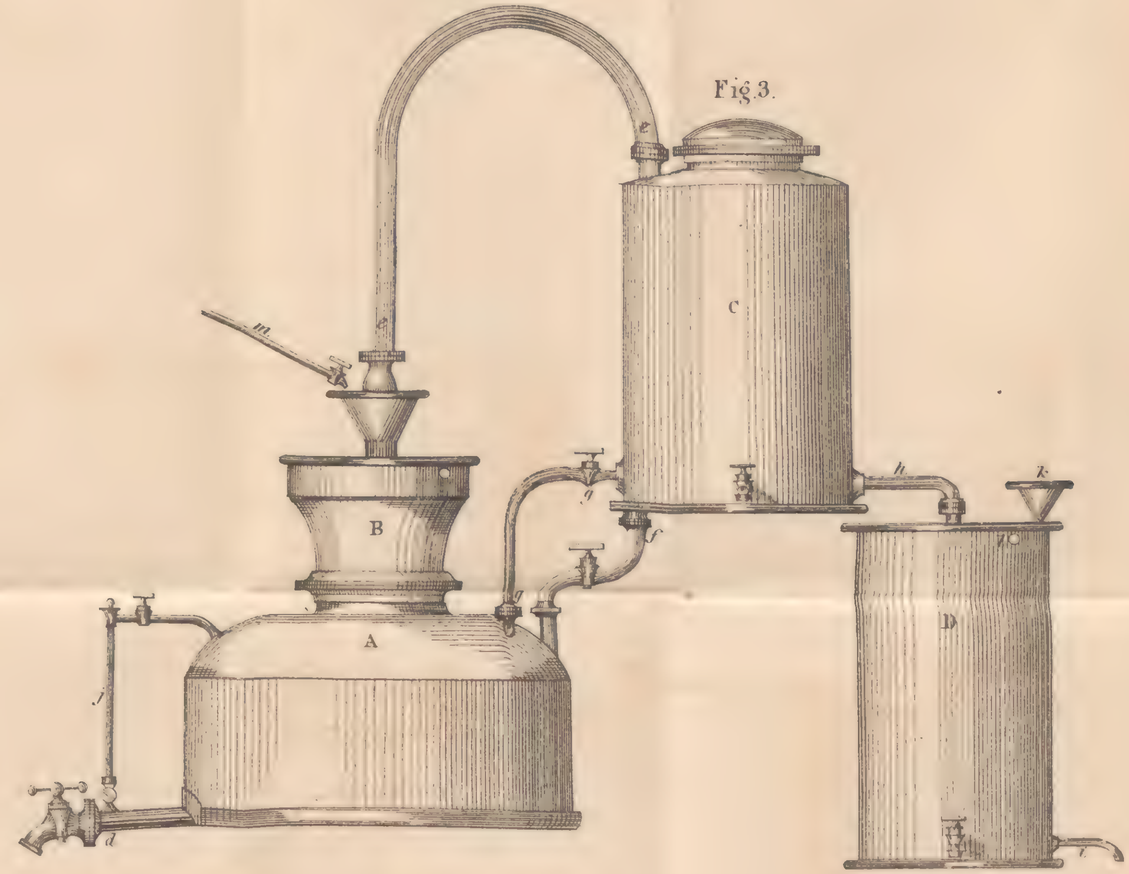


Fig. 3.



Pl. 6

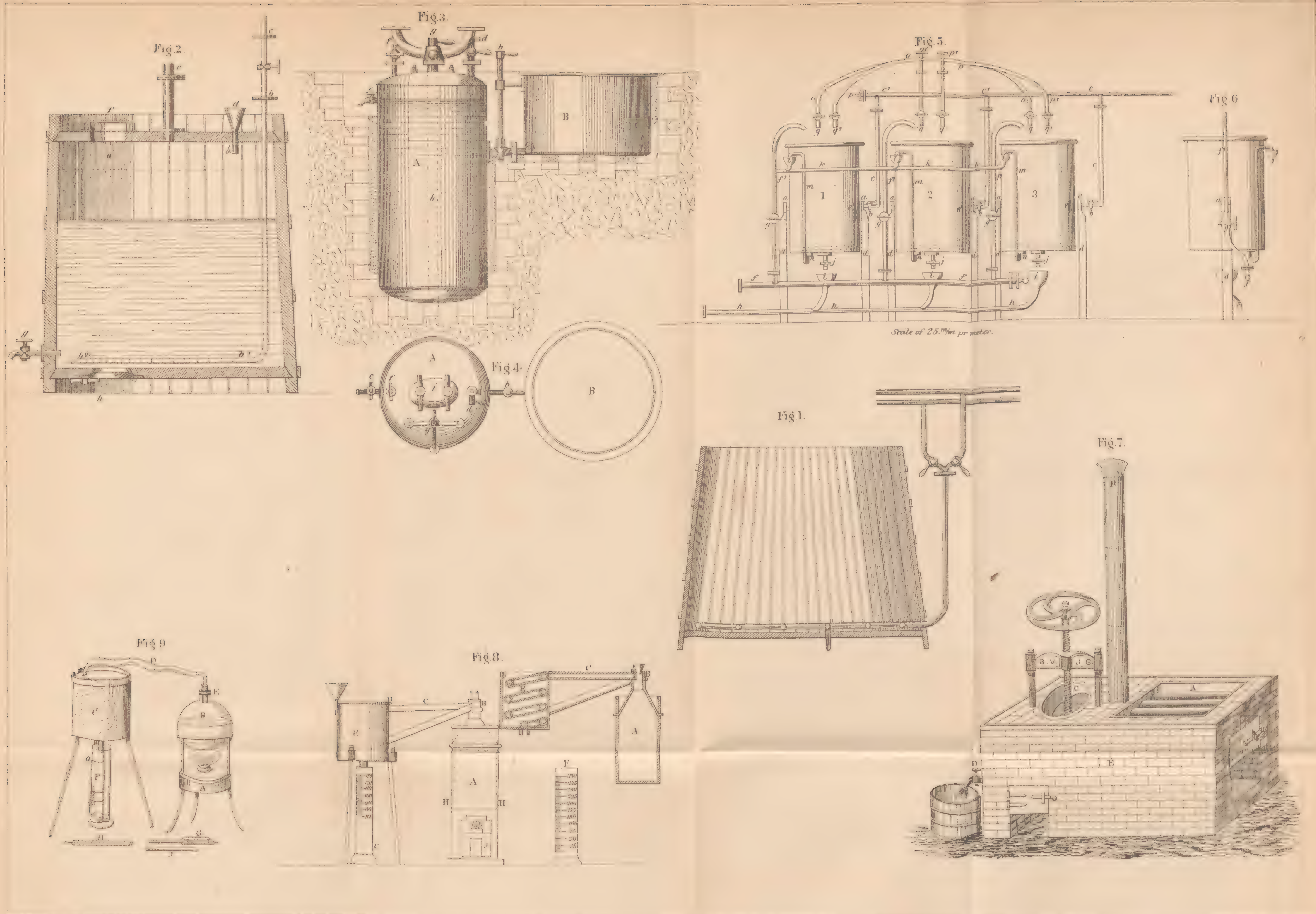


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Scale of 25.mm pr meter.
B. V.
J G.

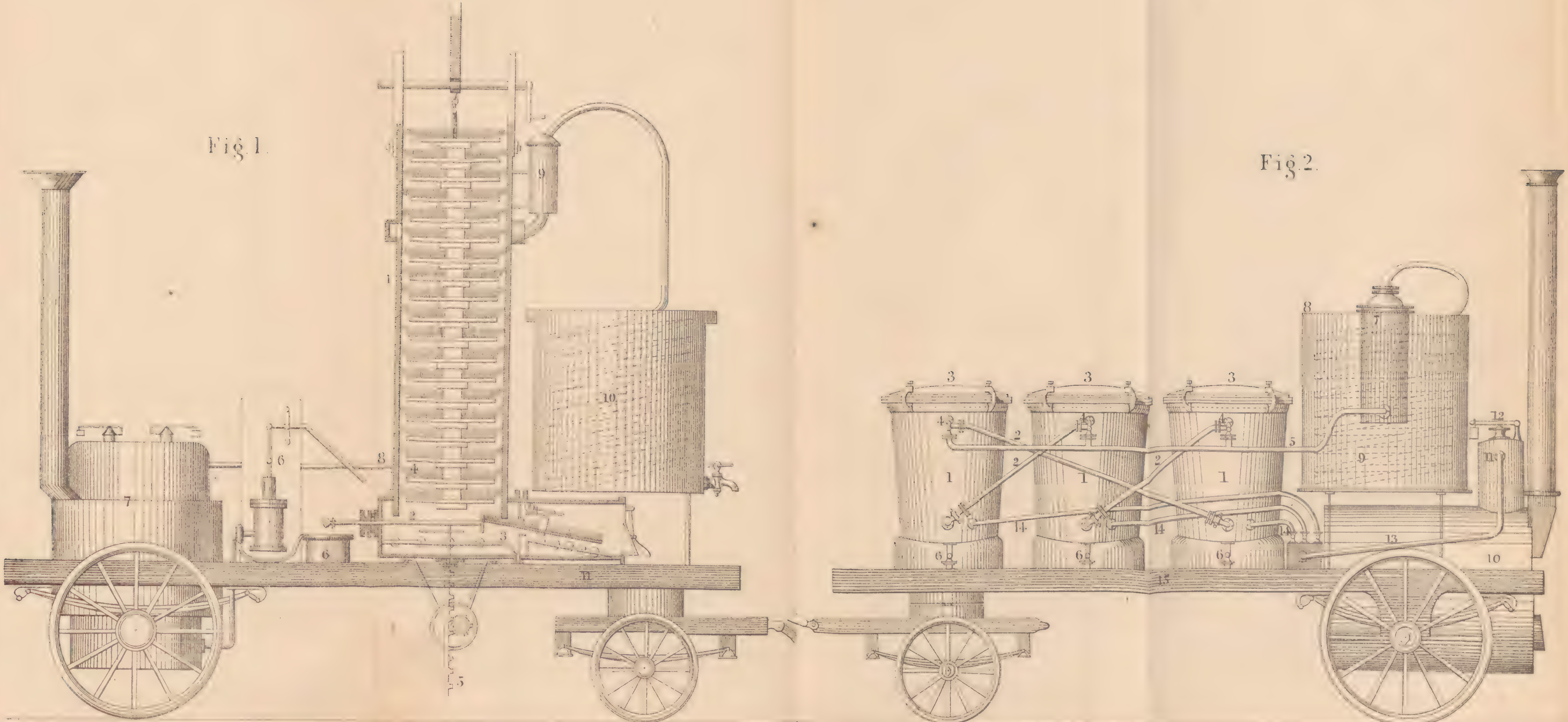
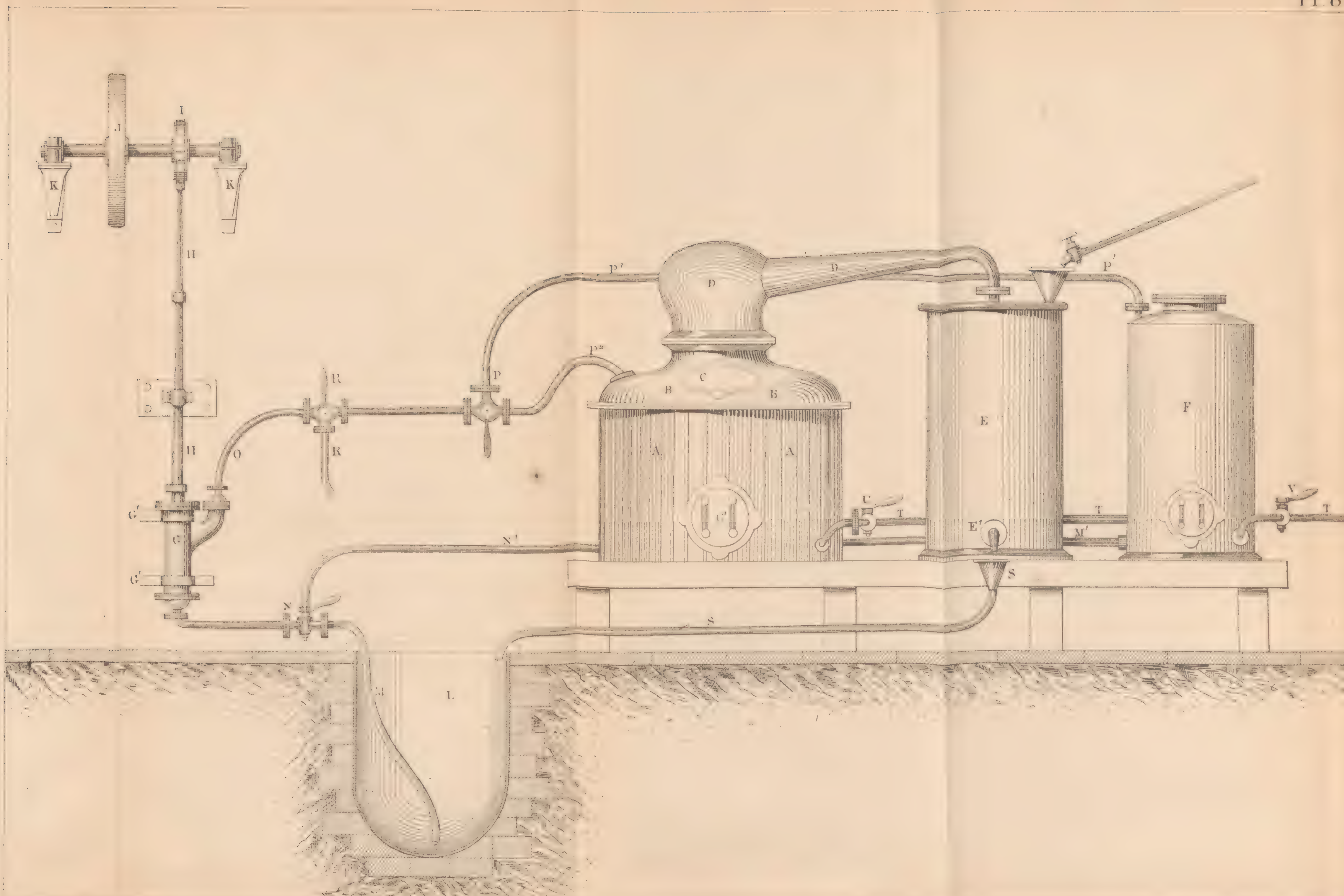


Fig. 1.
Fig. 2.


I
J
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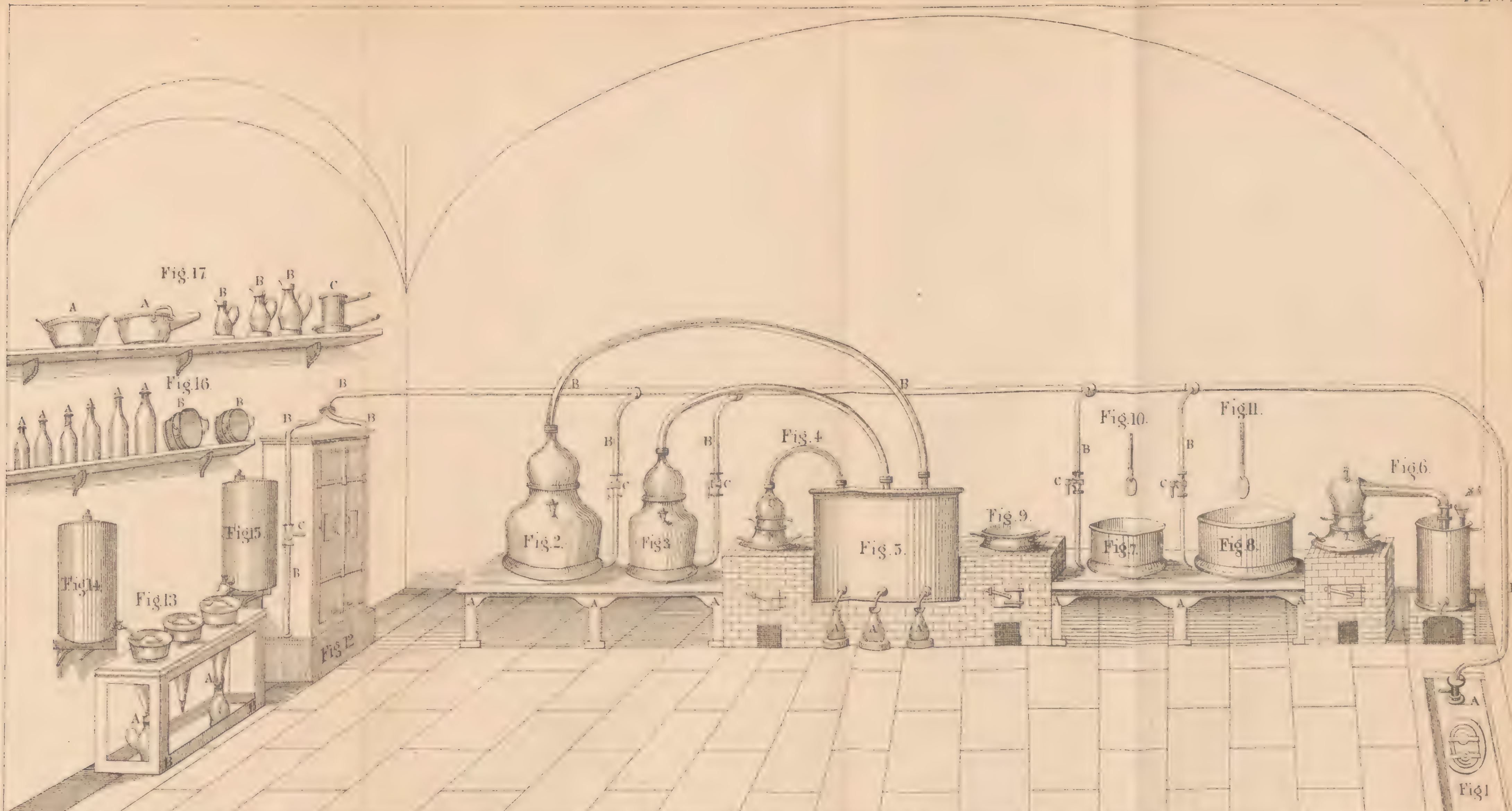


Laboratory of a Liquorist.

Fig 2.

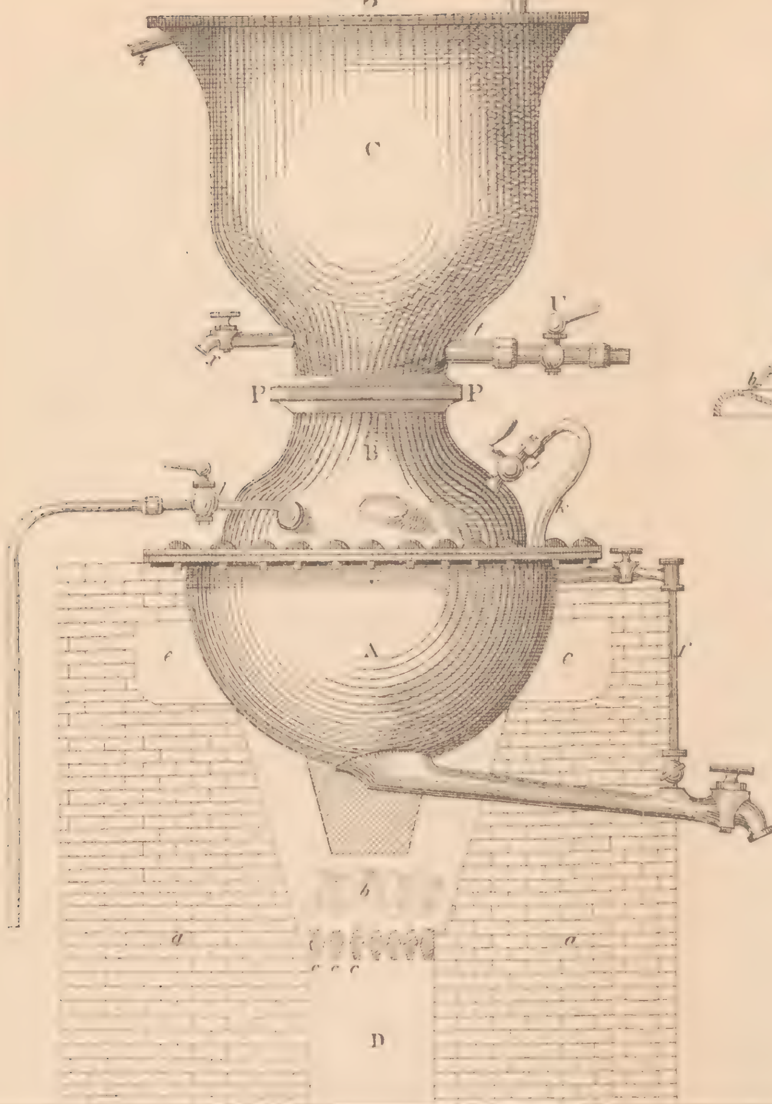


Fig.3.

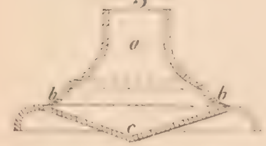


Fig.4.

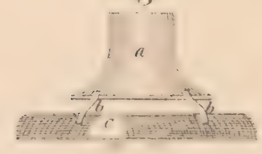
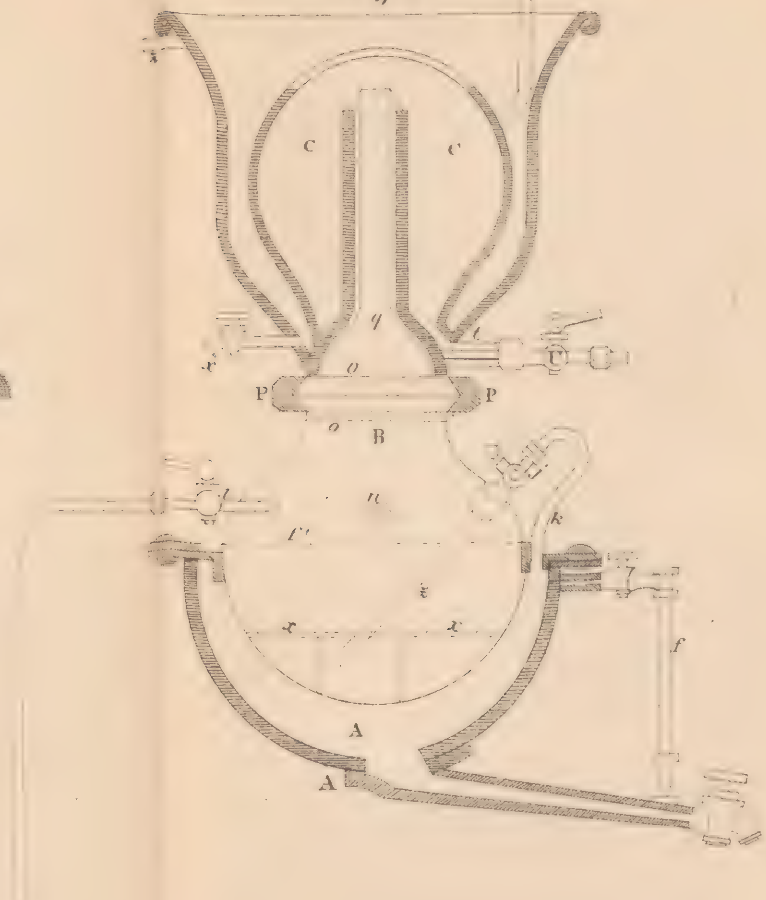
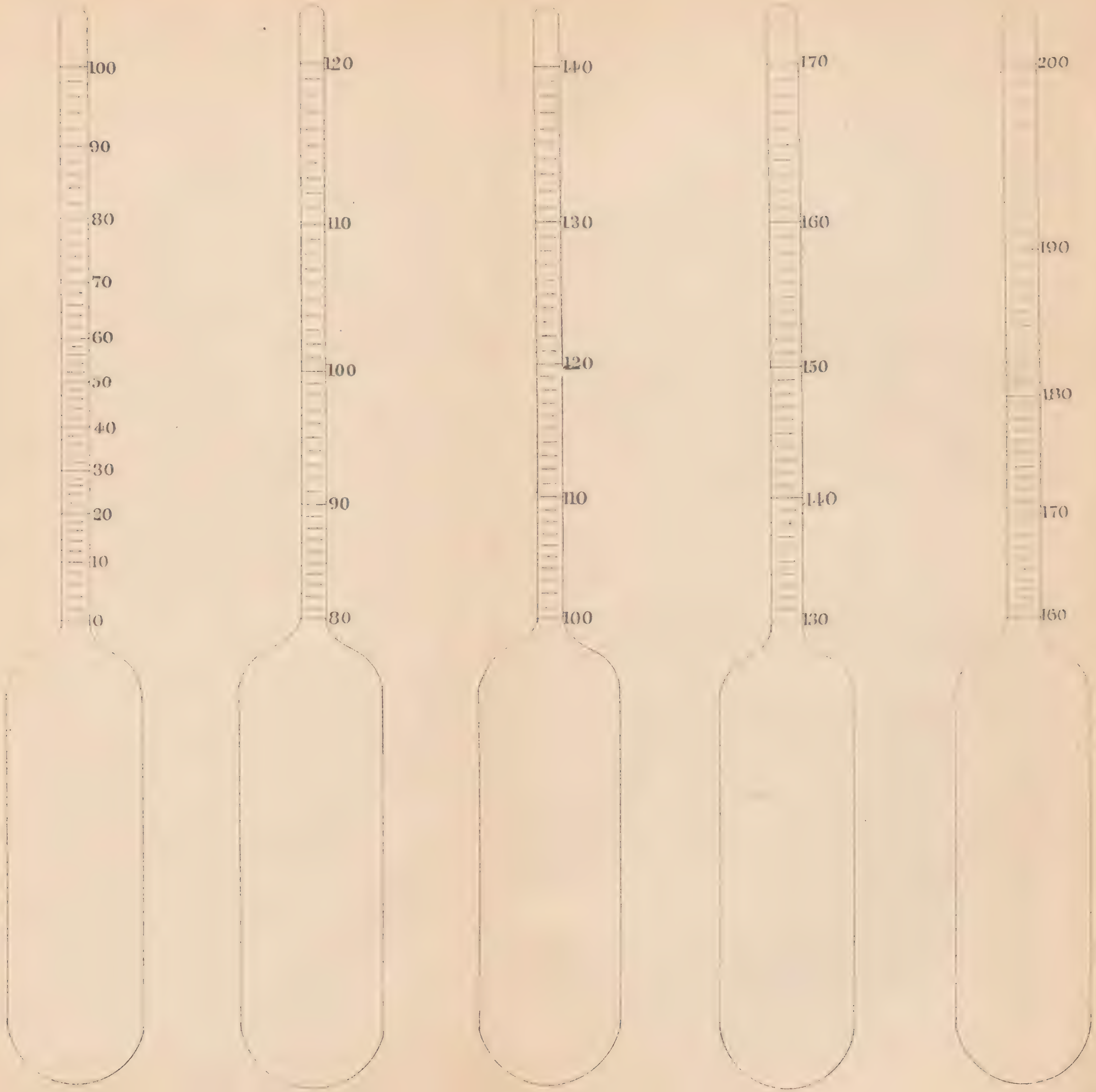


Fig.1.

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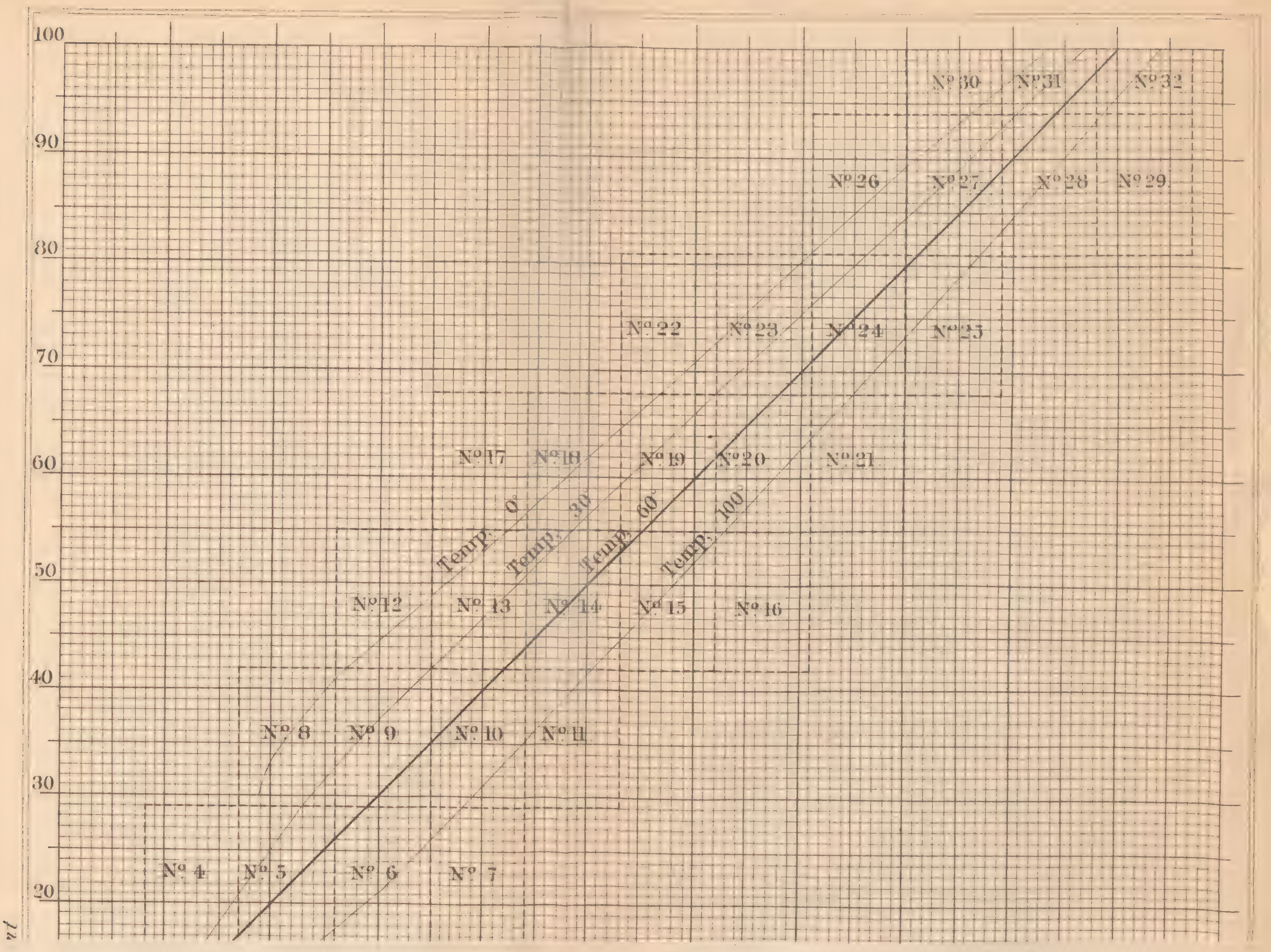
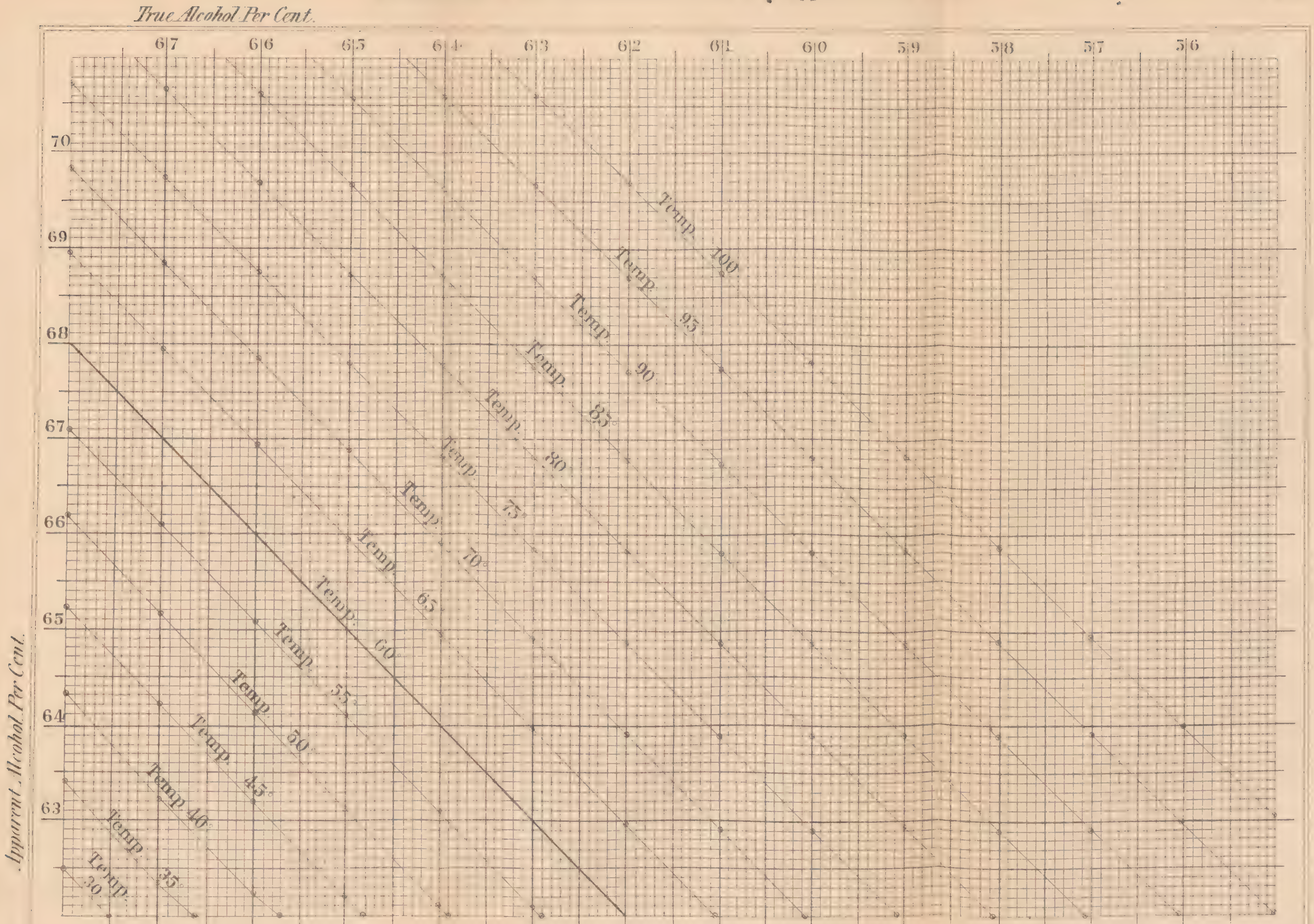


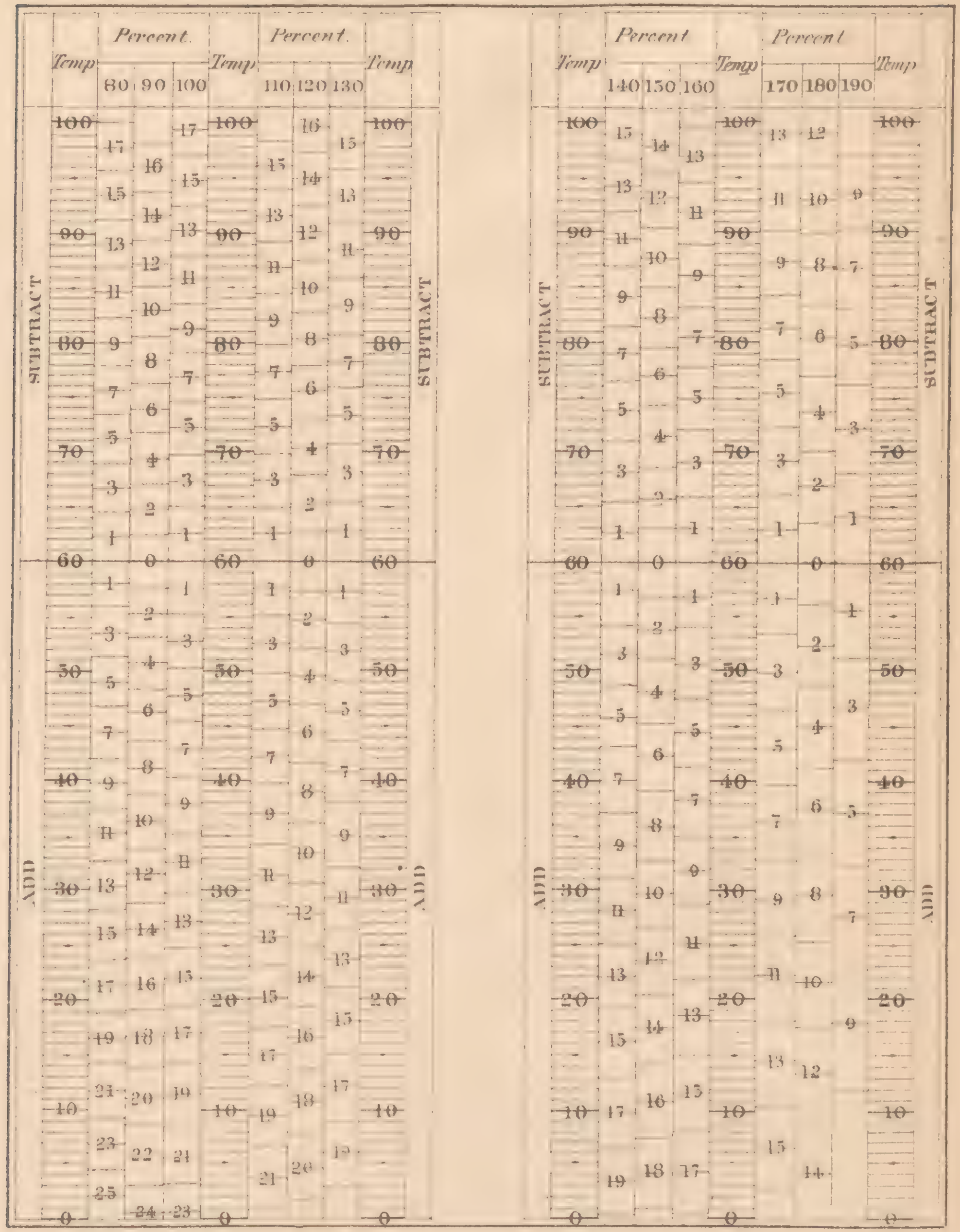
Specimen Sheet for Conversion of True into Apparent Per Cent. Pl. 13.



Temperature corrections for a hydrometer.

Showing per-cent of Proof spirit at 60° Fahr.

CORRECTIONS FOR TEMPERATURE. CORRECTIONS FOR TEMPERATURE. Pl. 14



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